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ENGINEERING:

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Drawings, Specification and a copy of the Conditions and Form of Contract may be seen on application to, and Bills of Quantities and Forms of Tender may be obtained from, Mr. J. L. MACGREGOR, H.M. Office of Works, 5, Drumsheugh Gardens, Edinburgh, on payment of One Guinea. The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. U 839

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EXTENSIONS, 1920.

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For each Specification of each type a deposit of £5 sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.
Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for New Aqueduct" and addressed to the Undersigned, must be delivered not later than Ten a.m. on the 7th August, 1922.
The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E.,
Water Engineer.

Water Engineer's Office,
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15th July, 1922. U 817

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Applicants who may be Associates of the Royal School of Mines or others, and preferably men with some practical experience, should apply in writing to the SECRETARY of the College (from whom further particulars may be obtained) before 1st September, 1922, giving the nature of the proposed investigation, qualifications for the work and references.
It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1923. Holders will be expected to devote their whole time to the work, which may be conducted at the Imperial College, or in special circumstances elsewhere at the direction of the Committee. U 840

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PORT IMPROVEMENTS AT BUENOS AIRES.

BUENOS AIRES, the chief port of the Argentine, is the concentrating point of an enormous volume of trade. The Argentine is not a manufacturing country, and is dependent upon its foreign trade for manufactured goods. In return for these it exports large quantities of wheat and other grains, live-stock, killed meat, wool, &c. The port of Buenos Aires is served by no less than seven important railways whose systems in the aggregate run to about 18,000 miles of line, extending in a network over a very large tract of country, as may be imagined when it is stated that in the Argentine the railway mileage is just under two per 100 sq. miles of territory. The seven systems are the Central Argentine, the Buenos Aires and Pacific, Buenos Aires Great Southern, Buenos Aires Western, Buenos Aires Central, Cordoba Central, and the Entre Rios. Most of these railways handle, in addition to traffic for local markets, &c., a large volume of export traffic in grain, wool, stock, &c.

No very recent figures indicative of the traffic of the port are available, and the conditions of the past few years have been so abnormal that little weight would attach to them in any case. Before the war, however, the value of the imports through the port of Buenos Aires amounted to more than 63,000,000*l.* per annum, with a steady tendency to increase. There was also at that time a fairly regular increase in the shipping making use of the River Plate ports. This growth resulted in the congestion of the port of Buenos Aires, and to meet this the authorities in 1908 decided to embark upon a large programme of extensions. The present dock area represents about 332 acres of water, with a total of about 65,594 ft. of wharfage available for shipping. A plan of the port is shown in Fig. 1 herewith.

The port is situated, as is known, on the Rio de la Plata, which carries a great deal of silt and is shallow for a good distance out. In order to improve access to the port two channels were dredged, known as the North and South Channels. These will be seen on the plan. The North Channel, 327 ft. wide, is dredged to about 28 ft. to 30 ft., while the South Channel has a depth of about 24 ft. The depth, however, is very dependent upon the wind, southerly winds increasing the depth, while off-shore winds from the north reduce the depth of water appreciably. The present accommodation consists of a series of basins and docks lying parallel with the shore and extending between the North and South Channels, together with a south dock extending southward from the end of the South Channel. There is further accommodation on the Riachuelo River. Owing to the difficulty which has been experienced in maintaining sufficient depth in both the North and South Channels to enable them to be navigated by deep draught steamers, the greater depth has been maintained in the North Channel, and this has led to the concentration of mail and passenger ocean-going steamer traffic in the North Basin and Dock No. 4. Docks Nos. 3, 2 and 1 are used by steamers with general cargo, as is also the South Basin. The South Dock is used by colliers, &c. The North Basin has a depth of about 30 ft., the tidal docks Nos. 1 to 4, 23 ft. 9 in. on the cill, and the South Basin and Dock about 22 ft. The accommodation is arranged so that imported cargo is discharged on the west side of the docks, and export cargo shipped from the east side. In the North Basin are two dry docks, 587 ft. and 488 ft. long respectively, and 65 ft. width at the entrance, with about 20 ft. of water over the cills.

The additions now being carried out are indicated towards the left-hand of Fig. 1, and are shown in greater detail in Figs. 2 to 5, while various views of the works at the present stage of completion are shown in Figs. 6 to 12, on Plates IX, X, and XI. As already stated, these extensions were decided upon in 1908 when the Argentine Government passed a law authorising contracts to be made for this work.

In 1909 a decree was issued approving the schedule of conditions governing the tenders to be called for the construction of the port, at an estimated cost, in the first instance, of 5,000,000*l.* In June, 1909, an extension of time was given to tendering firms, the date for submitting plans and estimates being then set down for December 1, 1909. As the Government merely fixed certain general particulars, such as depth of water, the approximate position of the new accommodation, and so on, a considerable amount of time was necessary for tendering as firms had to prepare complete projects themselves. The Government decided that the new docks were to be accessible from the North Entrance Channel which, as already explained, affords the chief means of access to the present docks, the Southern Channel, and the docks served thereby, being chiefly used by ships of smaller tonnage using the Southern Basin and privately-owned docks south of the Government docks.

In all, nine offers were received, four being from English firms, two from German, two from French, and one from an Argentine firm. All firms put in more than one tender, so that the total number of projects submitted amounted to no less than 51. As may be imagined, the work of selecting the most suitable one out of all these was a task of considerable magnitude. In June, 1910, a special committee was appointed to work in conjunction with Government officials, but it was not until April, 1911, that it was possible to recommend, out of all the schemes, the acceptance of the offer put forward by Messrs. C. H. Walker and Co., Limited, of Westminster. The delay caused by the necessary negotiations resulted in the contract period for the commencement of the works being ultimately fixed as May, 1912, the contract time allowed for completion being five years. In November, 1911, the Government issued a Decree naming Messrs. Livesey, Son and Henderson, 14, South-place, London, E.C. 2., as engineers for the work, this firm having prepared the various projects on which Messrs. Walker and Co. tendered. It is through the courtesy of this firm that we are now able to publish drawings, &c., of the scheme in hand. It may be stated that extensions on the lines thus decided upon, and contracted for with Messrs. C. H. Walker and Co., had been under consideration for several years before the work was actually settled upon. In the Argentine there appeared to be a difference of opinion on this matter. One party favoured the construction of the extensions to the south of the existing docks, the other preferring the northerly end. For various reasons the latter was ultimately adopted, among them being probably the fact that, as already stated, the Northern Entrance Channel has been maintained at large cost in a condition to pass the largest ships making use of the port. A second and very strong reason was to be found in the fact that railway and road access to docks at the north was much easier to arrange than in the case of any extension at the southern end. Another reason which lent weight to the decision was that the south was already provided with a considerable amount of wharfage on the Riachuelo River, while the Buenos Aires Great Southern Railway had then recently completed the Southern Dock, south of the Riachuelo. The present undertaking includes an

Fig. 1.

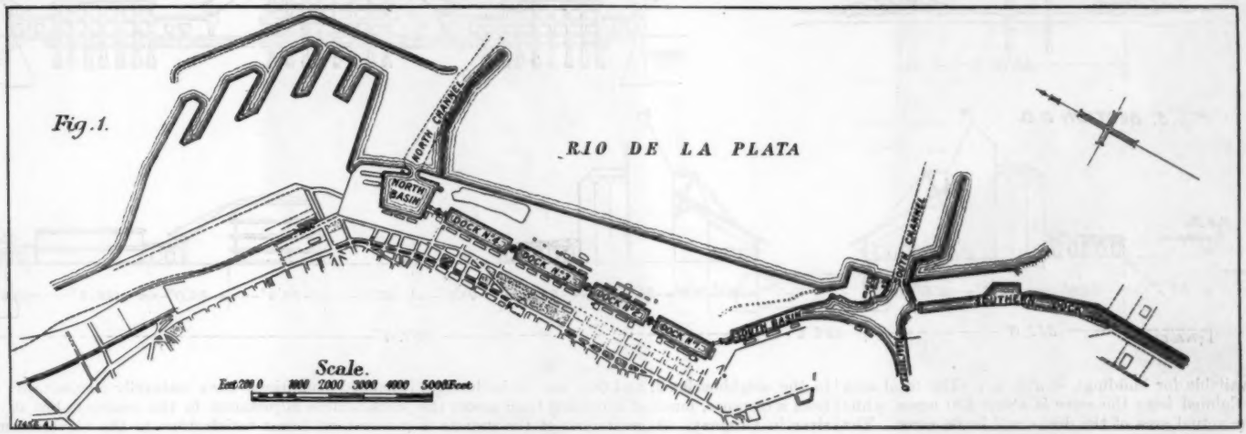
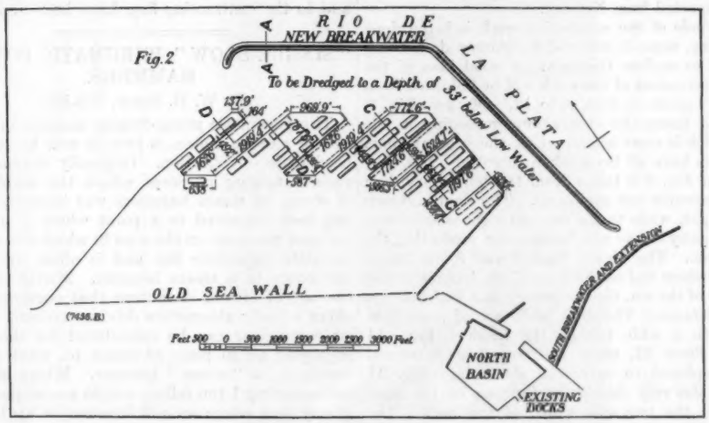


Fig. 2.


RIO DE LA PLATA
NEW BREAKWATER
To be Dredged to a Depth of 38' below Low Water
OLD SEA WALL
SOUTH BREAKWATER AND EXTENSION
NORTH BASIN
EXISTING DOCKS
Feet 500 0 500 1000 1500 2000 2500 3000 Feet

ante-port of about 82 acres, and four large docks so arranged on a large area of reclaimed land that future extensions of a similar character can be carried out immediately to the west of the present site. In Fig. 2 the position of the old sea wall is indicated. The outermost edge of the new dock walls will be nearly ¼ of a mile distant from the old sea wall. The intervening space apart from that occupied by the docks themselves and the necessary railways, sidings, &c., will be laid out in streets and will be available for buildings, stores, &c. The total area reclaimed from the river is about 830 acres, while the actual area of the docks will be 68 acres. The area of the moles now being built will be 106 acres. The area available for sidings, streets, buildings, &c., between the docks and the old sea wall, amounts to about 300 acres. The docks will comprise three of a width of 459 ft., and one of 492 ft. width. They are set facing east, and as will be noticed that nearest the ante-port is the only one that is rectangular. This dock has two sides, each 1,197 ft. 6 in. in length. The next has one side 1,524 ft. long, and one 1,724½ ft. long. The remaining couple have each one side 1,919 ft. long, and one 1,626 ft. The whole area is protected by a mole or breakwater about 1¾ miles long, while an extension of 656 yards has been made to the south breakwater protecting the Northern Entrance Channel. The latter was the first work to be undertaken. This breakwater consisted of a timber gantry filled in with stones resting on fascines. The outer breakwater has been constructed of loose stone with a hearting of smaller material. A section of this breakwater is shown in Fig. 3, and it has satisfactorily withstood several storms.

The quays will be provided with all the requisite accommodation in the way of transhipsheds, warehouses, &c. A section through one mole or quay on the line C C, Fig. 2, is given in Fig. 4. The layout of the two quays on this line C C are approximately similar. The provision in this instance will consist of a low transhipshed of two floors set back sufficiently from the edge of the dock, on each side, to allow for two tracks of 5 ft. 6 in. gauge railway, and a central warehouse of four floors. Railway tracks will be laid between the transhipsheds and the warehouses. The transhipsheds will be about 98 ft. wide; the warehouses will be nearly 119 ft. wide. Cranes will be provided along the edge of the dock capable of landing goods from the hold into the transhipsheds across the 49 ft. space which the latter are set back from the dock sides. The 124-ft. space between the transhipsheds and the warehouses will be commanded by cranes which will be capable of reaching both buildings. The sheds and warehouses are also connected by underground passages and bridges. The westernmost dock will be mainly employed for grain traffic, and the accommodation which will be provided in this case is shown diagrammatically in Fig. 5. There will be three lines of broad-gauge track on either quay, and behind these will be grain elevator and silo buildings. The total elevator and silo storage capacity to be provided will suffice for 265,000 tons of grain. The permanent railway lines and sidings will aggregate about 30 miles, while the paved roadways will represent something like 86 acres.

Altogether the length of wharf walls contemplated in the present scheme is about 3½ miles, and the walls will contain about 523,000 cub. yards of concrete and 636,000 cub. ft. of dressed granite. There is no suitable stone for the concrete aggregate in the neighbourhood, and this has to be brought from a distance, much of it coming from across the river in Uruguay. A great deal of the granite is being imported from Norway.

The whole of the excavation work is being done in the dry, some 5 miles of temporary dam being required to enclose the area. A good idea of the nature and extent of the work will be obtained from the views given in Figs. 6 to 12. Of these Fig. 6, Plate IX, shows the excavation proceeding in the dock which is most advanced at the present time. The views have all been taken recently. The view shown in Fig. 6 is taken from the temporary dam looking towards the mainland. The dam is shown to the right, while to the extreme right is to be seen the extremity of the new breakwater protecting the whole area. The views, Figs. 7 and 8, are taken from the shore end of the same dock, looking in the direction of the sea, the temporary dam being shown in the distance. The dock walls are of mass concrete with a wide toe on the inside. Figs. 11 and 12, Plate XI, show the travelling structural work employed to carry the shuttering, Fig. 11 showing also very clearly the junction of the head wall with the two side walls, of the dock. The upper portion of the walls can be seen faced with granite, in Figs. 7, 8 and 10.

The latter, Fig. 10, shows some of the transhipsheds nearing completion. These are of reinforced concrete and are carried on reinforced concrete columns and foundations. A view of two other sets of sheds in course of construction is given in Fig. 9, which shows the columns in position before the dock walls have been completed and raised to final ground level. The warehouses and sheds will have a floor area of 67 acres and will require a total of 153,000 cub. yards of concrete with reinforcement, The total excavation required will amount to about 3,540,000 cub. yards, all of which will be utilised for raising the ground level of the quays, and of the area up to the mainland. Dredging to the extent of 7,325,000 cub. yards will also be required, as the basins and docks will provide a depth of water of 33 ft. A good deal of this material is also being deposited on the reclaimed land. The material at the site is practically compacted sand, passing in places almost into a soft rock which, however, is easily worked. At the same time it stands up excellently when cut, as may be gathered from several of the views we give, and this fact has, of course, greatly facilitated the trenching work required for the mass concrete walls. The view, Fig. 12, for instance, shows a vertical backing cut to a considerable depth without timbering, although actually when that view was taken a good height had already been filled in with concrete. The view Fig. 6 also shows how clean the excavation work is.

The work is at the present time about 50 per cent. completed. Construction was seriously interrupted during the war, owing to the difficulty of obtaining materials, while for some time after the armistice labour troubles made satisfactory progress difficult. Work is now proceeding at a good pace. The changed conditions have naturally necessitated a considerable adjustment in the contract, but it is understood terms satisfactory to the Government and to the contracting firm have been arrived at.

Fig. 3. SECTION A.A.

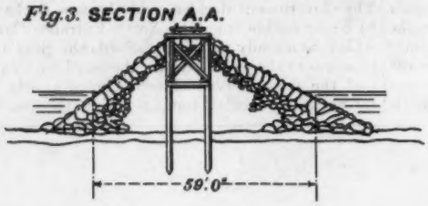


Fig. 4. SECTION C.C.

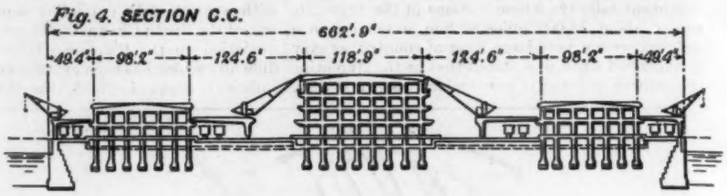
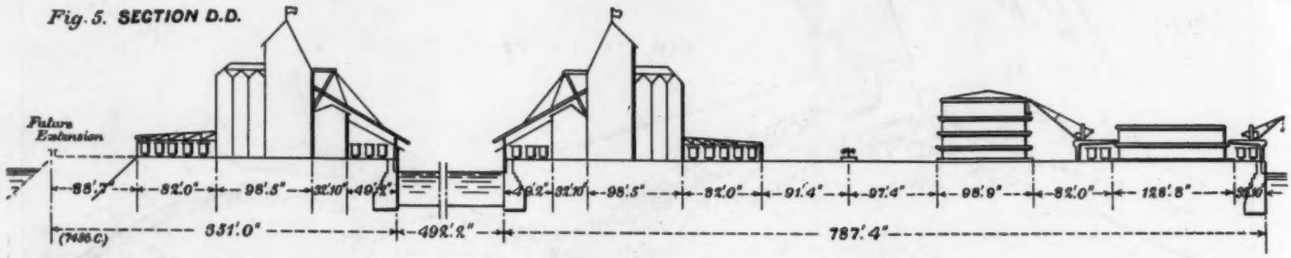


Fig. 5. SECTION D.D.



"SINGLE-BLOW" PNEUMATIC FORGING HAMMERS.

By W. H. SNOW, Wh.Ex.

THE pneumatic power-forging hammer driven by belt or electric motor, is now so well known as to need little introduction. Originally developed for general forging purposes where the employment of steam in steam hammers was inconvenient, it has been improved to a point where it provides, for most purposes (in the sizes in which it is made) a complete substitute for, and is often adopted in preference to a steam hammer. Merely to avoid the use of steam, it is true that compressed air offers a ready alternative driving medium, and an air compressor can be substituted for the boiler, supplying air in place of steam to, what remains essentially, a "steam" hammer. Where hammers not exceeding 1 ton falling weight are in question—at any rate where an odd hammer or up to three or four are concerned—the power hammer is available and can be used with considerable gain. Being entirely self-contained and itself providing the compressed air for actuating the hammer head, it possesses obvious advantages in convenience and first cost over a dual installation of hammers and compressors. The factor, however, decisively in its favour is its high efficiency, making it a very cheap tool to run. Sixty per cent. to 70 per cent. of the energy put into the flywheel is obtainable as blow energy, which is more than double the figure possible with compressed air used in the ordinary way, even when associated with every practical device for promoting economy.

For the high efficiency of the self-contained pneumatic hammer we have the following reasons. There being neither admission nor exhaust of the air in the sense ordinarily understood, two usual main causes of loss of efficiency, viz., (1) "clearance" and (2) "incomplete expansion," are entirely absent; expansion is carried right down to the intake pressure. Considerations of clearance which in the compressed air or steam hammer lead to a limitation of port and valve areas, do not arise in the self-contained hammer, and all air passages being of ample area, "back pressure" (3) does not occur, and this item of loss is avoided. Then something is saved in (4) "heat losses" owing to

(To face Page 98.)

THE EXTENSION OF THE PORT OF BUENOS AIRES, ARGENTINA.

MESSRS. LIVESEY, SON AND HENDERSON, LONDON, ENGINEERS; MESSRS. C. H. WALKER AND CO., LIMITED, WESTMINSTER, CONTRACTORS.

(*For Description, see Page* 97.)

FIG. 6. VIEW OF ONE OF THE NEW DOCKS, LOOKING FROM THE TEMPORARY DAM TOWARDS THE MAINLAND.

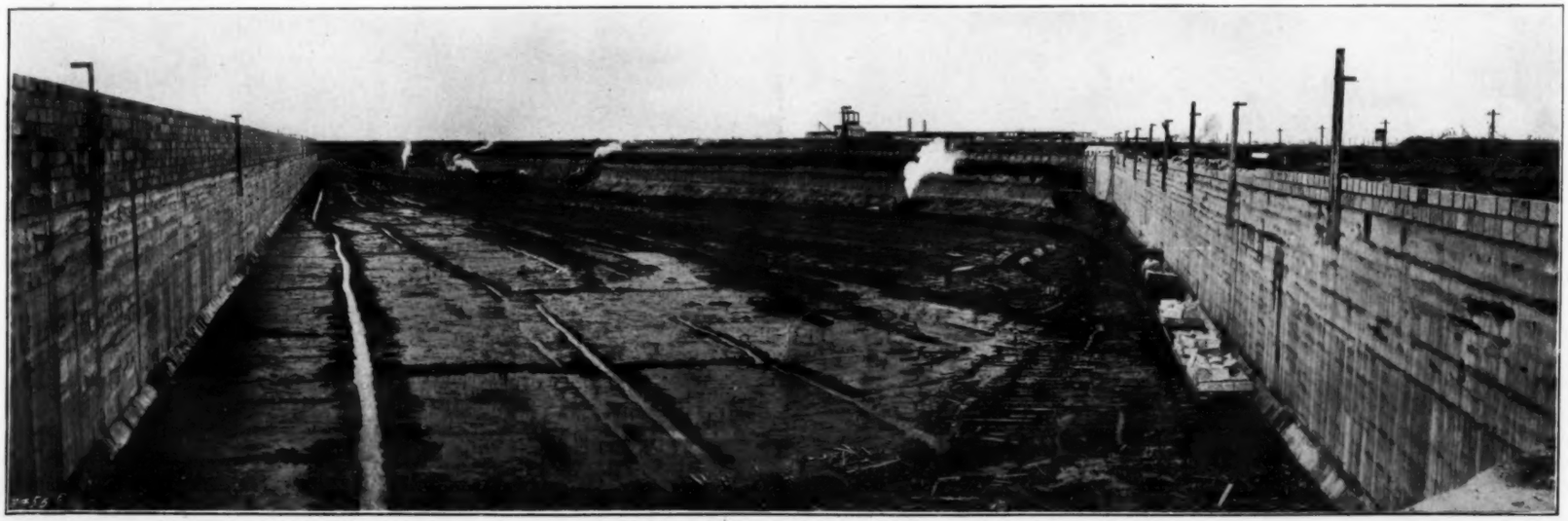


FIG. 7. VIEW OF ONE OF THE DOCKS LOOKING FROM THE SHORE END IN THE DIRECTION OF THE OPEN WATER.

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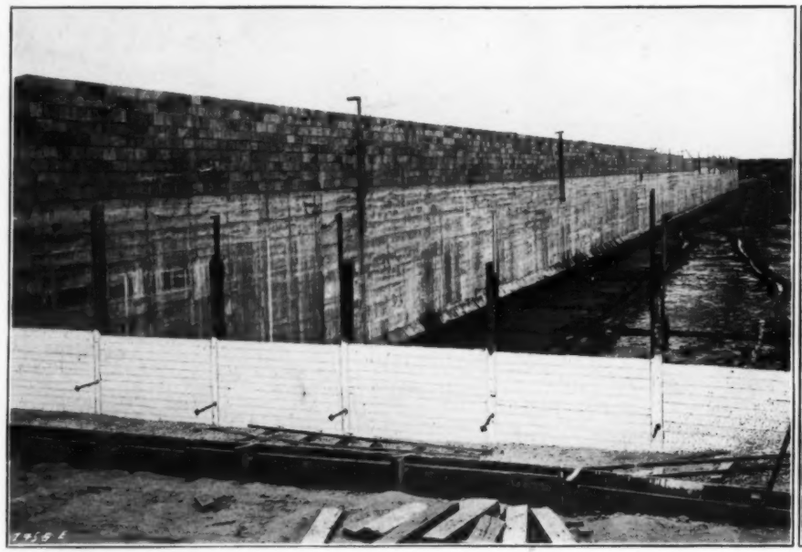
(*For Description, see Page 97.*)



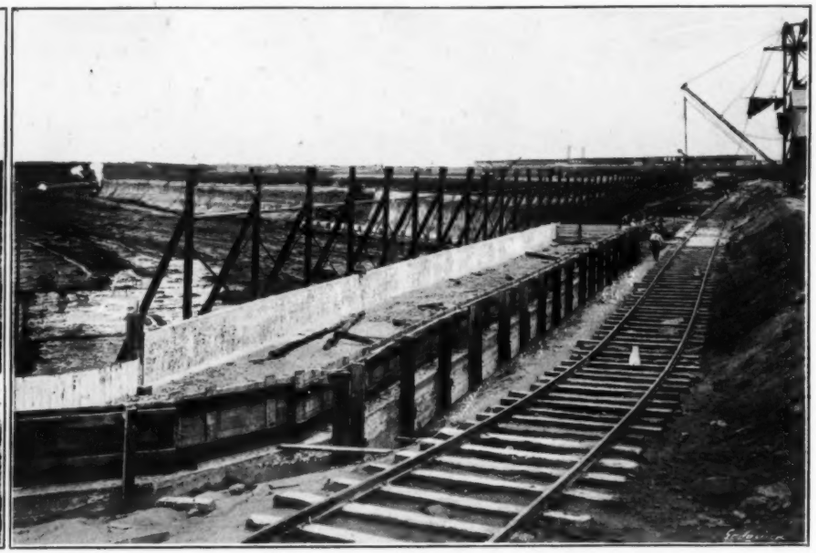


FIG. 8. VIEW OF ONE OF THE DOCKS, SHOWING SHUTTERING AND CONSTRUCTION OF END WALL.

FIG. 9. QUAY WALL AND TWO ROWS OF TRANSHIP SHEDS DURING CONSTRUCTION.

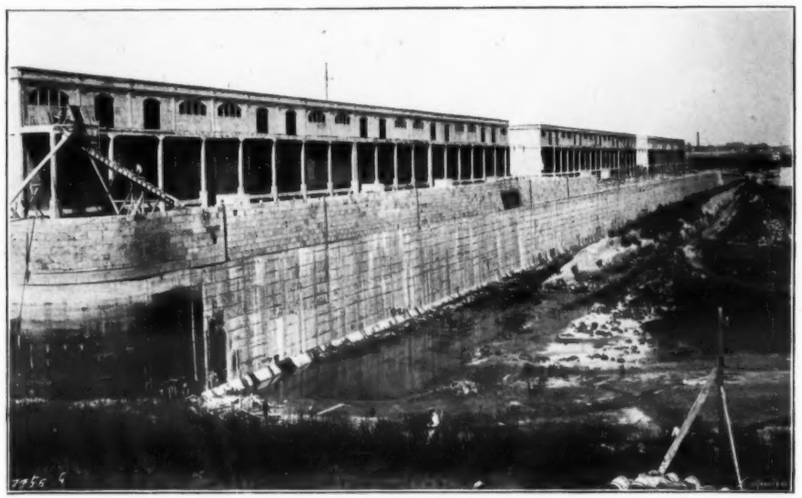


FIG. 10. VIEW OF QUAY WALLS AND TRANSHIP SHEDS.

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(*For Description, see Page* 97.)

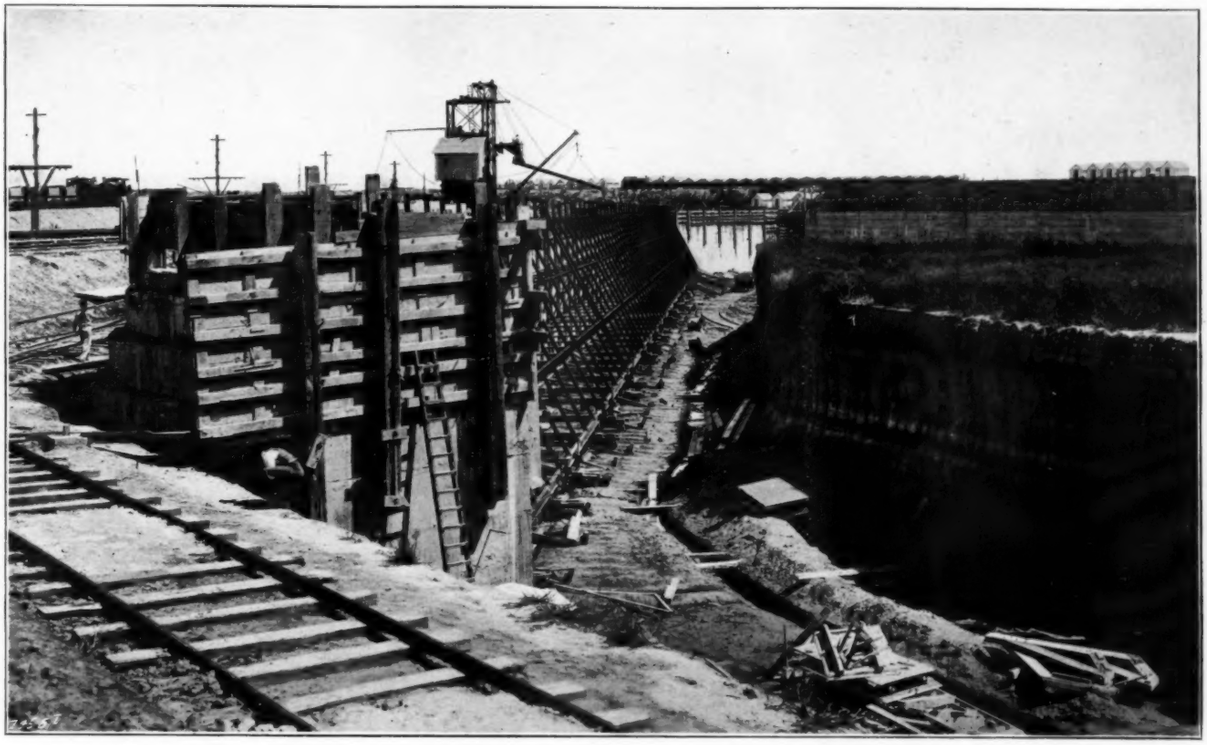


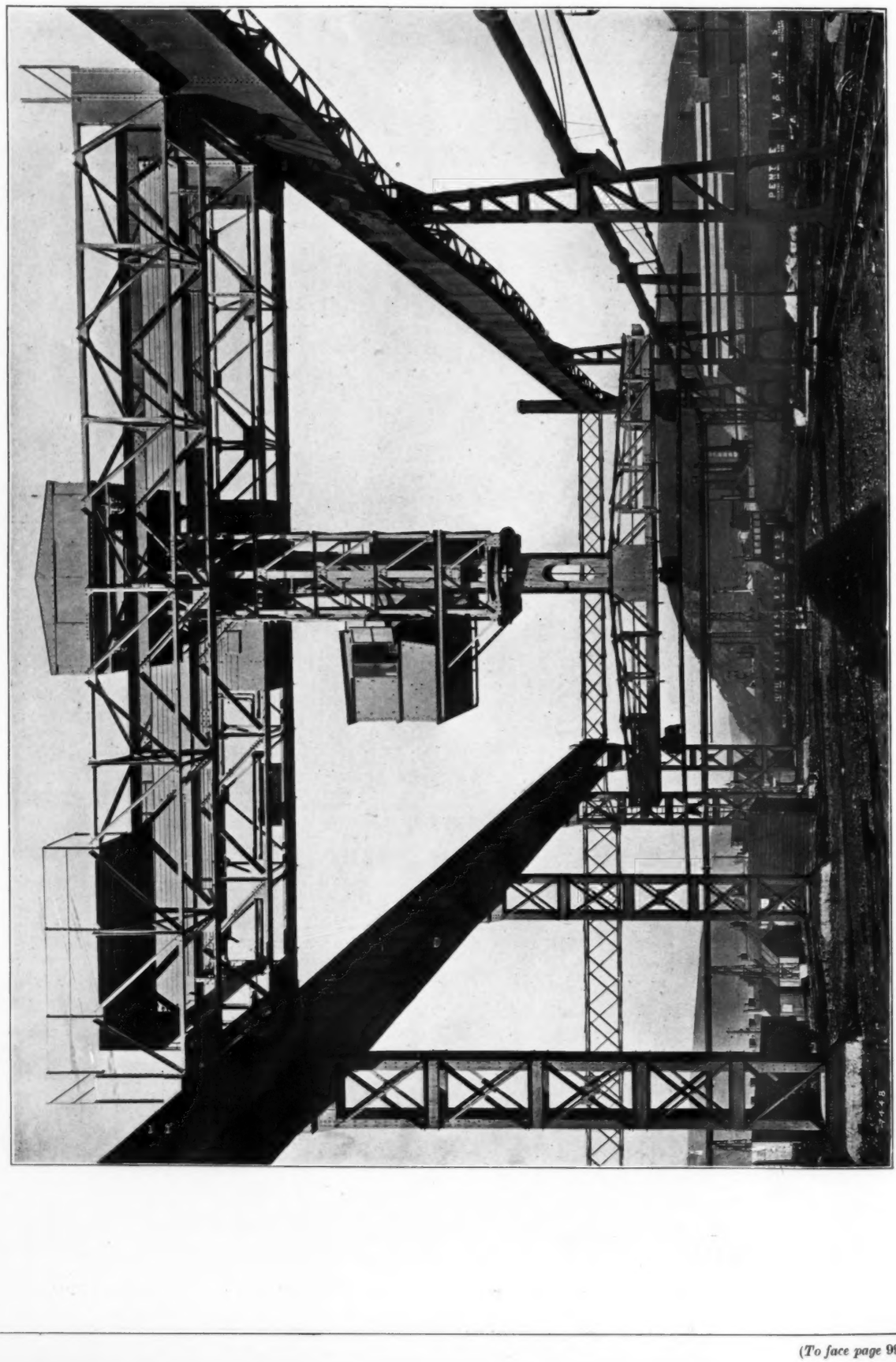
FIG. 11. VIEW OF SHUTTERING USED AT JUNCTION OF SIDE AND END WALLS OF DOCK.

FIG. 12. TRAVELLING STAGING USED FOR SHUTTERING IN CONSTRUCTION OF MASS CONCRETE QUAY WALLS.

5-TON OVERHEAD TRAVELLING MAGNET LIFTING CRANE.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, PARKHEAD, GLASGOW.

(*For Description, see Page* 103.)



(*To face page* 99.)

the air being used at the instant of compression, and, what is equally important, being compressed only to a "low pressure" (5) of 25 lb. to 30 lb. per square inch. Following on this latter fact "leakage lines" (6) are low as compared with a hammer using air at 80 lb. or 100 lb. per square inch pressure.

The figure given for the efficiency applies only to full blows, and the all-round efficiency is lower. In arriving at the energy taken for any given forging operation, the efficiency on light blows and when "holding up," &c., must be taken into account. The subsidiary operations of holding-up and holding-down involve the use of the air compressed by the pump in much the same way as occurs in an ordinary hammer accompanied by the usual losses. The high efficiency of the major operation is essentially bound up with the automatic action of the power hammer, the blows being produced at just the same frequency as the revolutions of the compressor crankshaft. For each blow the air between the pump and hammer pistons undergoes a cycle of compression and expansion, and the same air is used repeatedly acting, in fact, as a spring connecting the two pistons. The reciprocating movement given to the pump piston results in an up and down movement of the hammer piston, of the same frequency as, but not in the same phase with, and having a different "wave formation" to, that of the pump piston movement, to use the simile of the alternating electric current. The "air spring" transmitter may be single, alternately extended and compressed as in the "vacuum" single-acting hammer, or there may be two compression springs as in the double-acting "pressure" hammer. Owing to there being no break in the flow of air between the pistons, nearly all the work done on the compressor piston and put into the air is passed on to the second piston. In the ordinary use of compressed air, the necessary dividing up of the process into compressing, delivering, storing and utilising, results in losses at every step. The ordinary air cycle of compression-delivery, and admission-expansion, is replaced in the power hammer by the simple one of compression-expansion. Clearance loss due to admitting air, which has been compressed to the maximum pressure, to a space where the pressure is lower, does not occur, as the pressure of the air on the hammer piston is raised gradually, and the hammer and pump cylinder spaces on either side of the pistons (double-acting hammers here being understood) are always at the same pressure at any instant. As soon as the maximum pressure is reached, expansion follows. If the expansion is not fully completed at the end of the hammer stroke, the air expands further by the continued movement of the pump piston until the intake pressure is reached, work being thereby returned to the pump. The item of loss occurring in compressed air hammers due to exhausting air not fully expanded is thus not present in the power hammer.

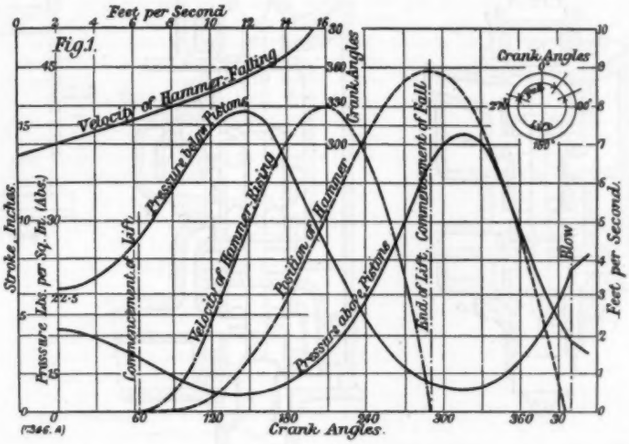
For a better understanding of the relation between the movements of the pump and hammer pistons the diagram, Fig. 1, has been drawn. The curves for the hammer movement cannot be calculated in the same way as for the case of a compressed air hammer from an indicator diagram, which can first be readily constructed knowing the supply pressure, cut-off point, &c. The compression curve for the power hammer obviously depends on the movement of the hammer as well as the pump piston movement, and only the latter is known beforehand. The movement of the hammer has to be obtained tentatively by assuming the compression curve over short intervals, derived in part from the pump piston movement; the correctness of the result obtained from such assumptions having then to be checked by seeing that the proper correspondence exists between space and pressure. The construction of indicator diagrams follows, and these are shown in Figs. 2 and 3.

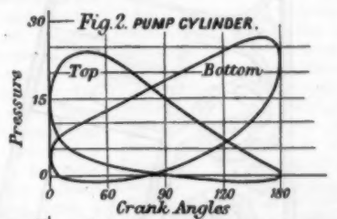
The normal blows of the pneumatic power hammer as ordinarily made, are, as will be seen from the foregoing, not under control in regard to speed or frequency as are the blows of compressed air or steam hammers, in which latter a valve is used for controlling the flow of air for each blow and the movements of which can be regulated to vary both force and speed of blow at will. In regard to force, complete control is obtained in the power hammer by suitably designing the change-over valve. This valve, arranged between the pump and hammer cylinders, effects by simple alteration of position, the changes in the pressure and flow of the air necessary for the different operations of hammering, holding up, &c., there being a fixed position of the valve for each operation of the hammer. The author's design for small double-acting hammers is shown diagrammatically in Fig. 4. Before this was introduced the design Fig. 5 was used which produced a variation in blow by causing the stroke to shorten, air being by-passed on both sides of the pump piston to an equal extent. The force of blow for a given stroke in this case could not be less than that resulting from the free fall; and, for the lighter blows, the very short strokes with which they were accompanied caused the hammer to dwell on the job and cool it rapidly and also made it difficult for the smith to move and turn it. The early hammers could be made to hit hard, but lacked the nicety of control of the steam hammer and came to be looked on as suitable only for rough plain work. In the arrangement, Fig. 4, air above the piston is by-passed for light blows through the non-return valve more freely than air from below is allowed to escape to the top. This causes the hammer to float on the bottom air, producing the elastic or cushioned light blow with a good length of stroke which is a prime necessity for all-round successful forging. A further feature of this valve is the construction in two halves, the front half engaging the back by means of a claw, the arrangement being such that a partial movement of the front half can take place while the back remains stationary. (In Fig. 4 the sections are shown separated, but in actual construction they are placed in tandem forming one valve on a single axis in one valve chamber.) When holding-up, the constant unbalanced pressure of the air on the back one-way valve causes the back half to stick. On the front half the pressure is intermittent, and during a considerable interval it can be moved easily. When moved, for the purpose of lowering the hammer, a small passage is opened allowing the compressed air holding up the hammer to escape, wherein the back half becomes relieved of pressure and the whole valve can then turn as one piece.

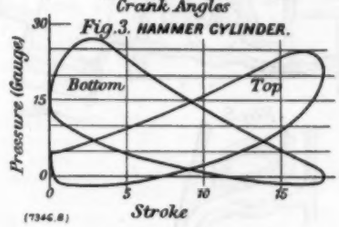
The simple rotary type of valve described is only suitable for the smaller hammers where the sticking due to inherent want of balance is not sufficient to give rise to inconvenience. For hammers of 7 cwt. to 10 cwt. and over, a piston valve, with symmetrically arranged ports in the valve chest giving complete balance, is essential for the practical reasons given, besides providing much more scope for improving the working and economy of the hammer on the subsidiary operations. Designs of piston valve by the author, for ordinary and for "singie-blow" hammers are shown in Figs. 6 and 7 respectively.

So far we have only dealt with hammers as ordinarily made in which the principal blows succeed one another at the same rate as the crank turns. Odd blows in double-acting hammers are struck, light ones, by moving the valve from "hold-up" to "not-working," heavier blows by first a careful movement of the valve as above causing the hammer to fall well under control, followed by a quick movement to the "blow" position of valve, and, after the blow, promptly returning the valve to the hold-up position. The quick movement must be timed to take place when the pump piston is nearing the top of its stroke, so that there is a full charge of air under the piston to produce the lift. In some makes of hammer a timing mechanism is used consisting of a releasing device on the valve rod worked from a cam on the crankshaft; but generally it is found that the trick of correct timing is easily acquired by the hammer driver without such aid.

It has been mentioned that when "holding-up" the pump acts more or less as an ordinary compressor. Air is drawn in through the inlet valves A A, Fig. 4, and is discharged after compressions through a back pressure valve on the change-over valve serving as a delivery valve, passing then to the hammer cylinder and raising the piston. It has also been remarked that with a piston valve (Figs. 6 and 7) there are greater possibilities of design than are afforded by the rotating type of valve. The piston valve is worked out to control the upper passages, allowing compressed air to be pumped into the upper end of the hammer cylinder as well as the lower. Thus a positive pressure "hold-down" is obtained whilst with Fig. 4 the hold-down is partly by suction and partly by intermittent pressure. The piston valve only requires to be made sufficiently long in order to intercept the upper passages between the cylinders, whereas to do this with the rotary type requires a second valve in a separate chamber. Besides obtaining a pressure hold-down, it is possible to arrange clearance spaces that can be thrown into the pump when it is working as a compressor so that after sufficient air has been compressed, no further compression takes place, and the pump then works with only a small







expenditure of power. With the other type of valve, regulation of the pressure is effected by leaving the by-pass partly open, letting some of the compressed air escape, a certain amount of power being thus wasted.

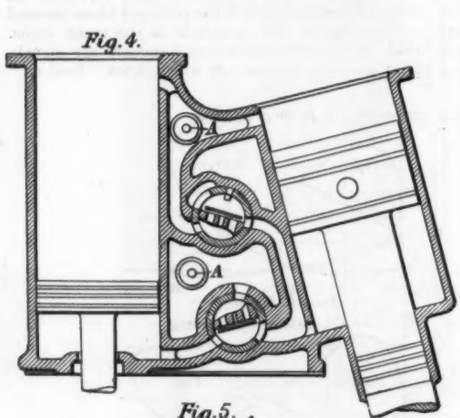
We are now able to pass on to the "single-blow" hammer. It will be seen from the foregoing that, with a valve contrived so that more use can be made of the pump as a compressor, and air can be led into the hammer cylinder above as well as below the piston, there exist the elements of a control of the up and down movements analogous to that obtaining in the ordinary double-acting steam or air hammer.

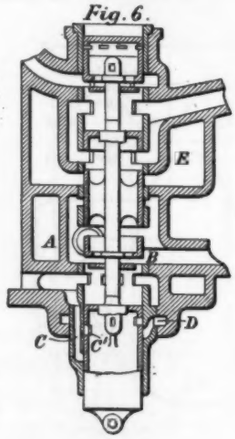
If the valve, Fig. 6, be moved from the hold-up to the hold-down position a single blow will be struck. Air compressed under the pump piston passes through the one-way valve B into the belt D and by a passage not shown, to the top of the hammer cylinder. The air below the hammer piston is exhausted through passages C in the tube and openings C^1 in the valve. The hold-up and hold-down positions of the valve are in this case adjacent, whereas in Fig. 4 they occupy the extremes of the valve movement and it is less easy to pass direct from one to the other. The force of the blow will depend principally upon the pressure and quantity of air admitted; the frequency with which single blows can be repeated will depend similarly. The hammer will not work as efficiently as when striking automatic blows, and thus only a slow rate of working can be expected. Assuming that, as a compressor, the pump absorbs the full power taken in automatic blows, then at the outside, the rate of production of single blows of the same force as the automatic, cannot be more than half that of the latter pressures already gone into. If the pump as a compressor does not work up to the full capacity of the driving motor, then the blows will be correspondingly slower.

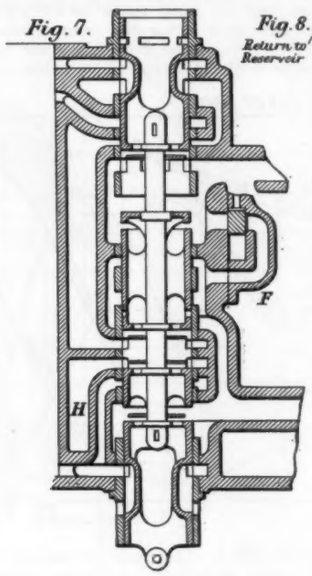
Actually with the valve arrangement, Fig. 6, single blows can only be produced comparatively slowly and, moreover, of only moderate force. In the first place the pump as compressor works single-acting. Only the down stroke is a working stroke. The upper end of the cylinder communicates with a clearance chamber and on the up stroke, air is compressed into this clearance, this air not being delivered up, but expanding back on the piston during the down stroke. A second feature is that the clearance E connected to the lower end of the cylinder for the purpose of limiting the pressure and making the compressor self-governing (already referred to) greatly reduces the volumetric efficiency and hence only a small quantity of air is delivered. Then there being no reservoir for storage of the compressed air, the blow depends very much on the position the crank happens to be in, when the valve is moved.

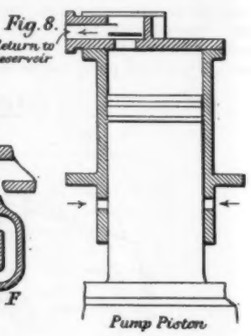
All the foregoing points are taken care of in the design, Fig. 7. Both ends of the cylinder are brought into use, and the pump works as a double-acting compressor. The governing is effected by a special rapid acting unloading valve, which opens a by-pass F when the maximum pressure is reached. Finally, storage of the compressed air is arranged for, in a reservoir formed in the cylinder casting (which can, if necessary, be connected to an outside receiver to increase the storage).

The single-blow, hand controlled, independent action in this case, where heavy blows can be struck at about one-third the rate of the automatic blow, becomes a real improvement, particularly in the larger sizes of hammers, enabling the miscellaneous processes of flattening, straightening, edging, setting, cutting-off and stamping, &c., to be carried out with precision, speed, and safety. The order of









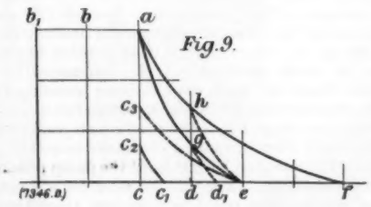
reservoir capacities, $a\,b$ and $a\,b_1$ being reservoirs of volumes 1 and 2 respectively, while $c\,d$ is the hammer piston displacement. The efficiency for $a\,b$ (ignoring compressor and clearance losses) $= \frac{a\,c\,d\,g}{a\,c\,d_1\,g}$ and for $a\,b_1 = \frac{a\,c\,d\,h}{a\,c\,e\,h}$. Suppose $c\,d = a\,b$ and pressure = 30 lb. per square inch (gauge). Then efficiency (1) = 90 per cent. and (2) = 78 per cent. The work obtained is given by the numerator. The work done in recharging is $a\,e\,c - c_2\,c\,c_1$ and $a\,f\,c - c_3\,e\,c$ respectively. The ratio of work obtained in the two cases is 1 : 1·30 and of work done 1 : 1·50. More work to the extent of 50 per cent. can be done in the air with the larger reservoir. The work obtained is 30 per cent. greater, the efficiency being less.

To avoid heavy clearance losses, the hammer must be worked with long strokes. The amount of air used for raising depends on the speed of rise. In order to give the compressor time to recharge between the blows, the supply to the underside of hammer piston is throttled by limiting the area of passage H—or a reducing valve can be introduced—so as to retard the rise.

Leakage of air from the reservoir back to the pump is unavoidable to some extent. The piston valve is of relatively large diameter and the number of leakage paths considerable. Hence there is a tendency for the pressure to fall somewhat rapidly after the by-pass pressure regulator has come into action and charging has ceased; and to steady the pressure and the working of the compressor, the arrangement, Fig. 8, can be used, consisting of an auxiliary pump designed to exhaust the air which leaks back into the compressor cylinder, and return it to the reservoir.

A few hammers have been constructed on these lines and have given very satisfactory results over several years; but bearing in mind the unfavourable conditions under which forging plant is generally expected to work, some doubt may exist regarding the prospects of a wide success. The extra first cost is an appreciable item, but worth while for the improved action, assuming that a high degree of reliability can be assured. A simple mishap, however, such as the failure of a valve or spring, may lead to the hammer working unsatisfactorily through the possibilities of wrong handling when the control valve and other parts come to be dissected and put together again by men accustomed to deal only with the ordinary plain equipment of a forge.

From the survey of what has been done to secure flexibility in the working of the pneumatic forging hammer, and render it as far as possible the equal of a steam hammer in handiness, as well as capacity, from the smith's point of view, it will be seen that to graft a successful hand-controlled action on to the



events in the operations of the hammer, beginning with the valve lever in the raised position is (1) hold-up, (2) hand blow (and hold-down), (3) not working (hammer at rest, pump bye-passed), (4) light automatic blows, (5) heavy automatic blows. The hand-worked blows are obtained by moving the lever up and down between positions 1 and 2.

The heaviest blow that can be struck depends on the size of the reservoir, the pump displacement during the short time the hammer is falling being too small to affect the pressure. With a small reservoir the expansion will be considerable and the mean pressure and force of blow will diminish. The efficiency improves with increased expansion, but on the other hand the charging up of the reservoir ready for a second blow proceeds from a low-pressure, and the work the pump can do in a given time is less than with a larger reservoir and smaller range of pressure. The best results are obtained with the latter enabling the pump and motor to work up to their maximum capacity; but if the reservoir is too large, the time taken to charge up after a period of automatic working, during which the reservoir pressure may have run down, may be inconveniently long. Diagram Fig. 9 shows the results obtained with different

automatic action, the pump must be utilised as a compressor in a set of functions distinct from those associated with automatic working. To utilise it at its best entails certain necessary complications such as a quick-acting pressure controller or governor and valve details for making the pump double-acting. By adopting something short of the complete arrangement described a single-blow action of sorts can be secured, but one which for practical purposes may be little more than nominal. From one-third of the frequency of the automatic blows, the production of single blows will fall to one-sixth if the pump is only single-acting, and to one-tenth or less if the special controller is eliminated and clearance governing resorted to. Storage of the compressed air is essential. The work must be done on the air in advance of the movements of the hammer piston—as a study of the diagram for the automatic blow shows—to obtain a good force of blow and complete control. In the "vacuum" lifted hammer it is possible in the ordinary way to strike a direct blow of moderate weight, from the raised position in one movement, but the blow is a glancing one, the tup rising immediately after striking; whereas for ideal control it is necessary to be able to arrest the up or down movement at any point. It is advisable where a single-blow action is claimed—perhaps with some insistance—for a hammer, to get satisfied as to what the claim really amounts to in practice. It has a special appeal to a smith accustomed to hand-worked steam hammers, a fact of which the salesman will make the most, and which should not be allowed to override the purchaser's judgment to the overlooking of other considerations.

CHEMICAL ENGINEERS CONFERENCE AT GLASGOW.

(*Concluded from page* 64.)

EVAPORATION.

Before evaporation can take place, the original liquid material must be converted into vapour, and the usual way of effecting this is by heating. This method is universal, except in so far as considerations of convenience or danger of destruction or chemical change of the material preclude its use. In such cases vaporisation can be produced at the original temperature by lowering the pressure to which the material is subjected, or by a combination of increased temperature with diminished pressure. Every liquid can be converted into vapour at any temperature by suitably regulating the pressure to allow evaporation to take place. The converse change, that is, the condensation of the vapour to form a liquid and complete the process of distillation by increase of pressure, is only possible at temperatures below the critical temperature. The necessary physical conditions governing both processes are thus exceedingly simple, and complexity is only introduced when other objects have to be achieved at the same time.

Evaporation is used to remove some portion or all of a liquid from a solution, or to vaporise the liquid incidentally to energy transference, as in steam raising or refrigeration processes. The latter category forms by far the largest process, and of this class steam raising is very notably the most important. The main object to be obtained in every steam boiler is the heat transference, with the minimum loss of the heat energy of the burning fuel, to the water contained in the boiler, the vaporised water or steam thus produced, being used for either power or heating purposes. Quantity, rapidity, or pressure of the supply of the steam or a combination of these factors influence the design of the boiler and very great progress has been made in the production of satisfactory plant. The requirements of maximum energy transference in minimum time have been met by the use of the results of numerous and varied experiments on the combustion of fuel and the mechanism of heat transfer through the walls of the containing vessel. The first problem is relatively simple, the criterion of its successful solution being almost invariably the attainment of a definite percentage of carbon dioxide in the flue gases. The second essential requirement of efficient boiler performance is much more difficult to achieve. In the consideration of economic steam production other factors, such as the first cost of the plant and maintenance charges are of great importance. Whether efficient in the sense of adequately meeting the heat exchange requirements or not, the plant must be sturdy and workable even with inefficient labour. Investigation has shown the existence of very tenaciously adhering films, of gas and water on the sides of the plate. These films are relatively bad conductors of heat, for it has been observed that even 90 per cent. of the temperature drop takes place in these films. Anything which disturbs or displaces the films promotes rapid steaming of the boiler because of the increased heat transmission.

The effect of the velocity of movement on the films produced in the cases of water, steam and air have been investigated by the late Dr. Nicolson, Professor A. L. Mellanby and their assistants, but so far there is little work available relating to the heat transfer through a plate to a medium containing large quantities of dissolved matter.

In evaporating plants used in the chemical industry, the problems are of a somewhat different character from those of the boiler, as their function is to use heat to vaporise a solvent and consequently leave a much stronger solution. The old plants for this purpose had the form of open vessels with the top surface of the liquid freely exposed to the atmosphere. They were heated by an external fire. The efficiency of such an arrangement is very low, except in those cases where the hot gases were made to play upon the surface of the solution. The form in which the liquid is heated has also a large effect upon the rate of evaporation. In some types of plant made for the drying of milk, the fluid is sprayed into a chamber in the path of the hot gases and very rapid evaporation takes place. Closed evaporators are of many types ranging from a simple vessel worked at atmospheric pressure and heated with fire or steam, to the plant in which reduced pressure is used in stages in many effects. In the latter system every pound of steam condensed in the heater coils of the first stage gives up its latent heat, which is utilised in evaporating some of the liquor, but also to a very small extent in radiation and conduction losses. The steam so liberated from this stage can be made use of as the heating steam for the following stage, liberating steam from the liquor in it which would be carried as heating steam to the next stage, and so on. If the pressure is reduced in stages it is possible to obtain a very efficient installation, and a total evaporation of a number of times the quantity of steam taken from the boiler. The designs of evaporators making use of this principle must be different for the many substances dealt with, because of their varying physical properties.

THE GENERAL PROBLEM OF EVAPORATION.

At the evening meeting on Thursday, the 6th inst., Mr. J. Arthur Reavell was chairman, and the first paper read was by Professor J. W. Hinchley, Wh.Sc., F.I.C., Professor of Chemical Engineering in the Imperial College of Science and Technology, whose subject was "The General Problem of Evaporation." The lecturer divided the subject into the two cases of evaporation below the boiling-point of the liquid and at the boiling point. In the former case, it is frequently stated that the rate of evaporation is proportional to the difference between the vapour pressure of the liquid and the vapour pressure in the air, but investigation, the author stated, had shown this to be not exactly true, and he had found that the equation

$$W = \left(\frac{p_e - p_d}{50}\right)^{1\cdot2}$$

gave reasonable results, where W = rate of evaporation in kilograms per square metre per hour from water surfaces, p_d = vapour pressure of the liquid in millimetres of mercury, p_e = vapour pressure of the water vapour in the air, using the same units.

This equation has been tested, and it was said should give accurate results for any solution if the change in vapour pressure of water when a salt is dissolved in it is taken into account. The author explained that the index used in the equation was necessary because evaporation prevented the existence of still air conditions. There is a considerable variation in the views of experimenters regarding the effects of a draught of air over the surface of an evaporating liquid. The results show in some cases strict proportionality to the velocity, in other cases to the square root of the velocity and again to a small power (0·3) of the velocity. Professor Hinchley considers the wet and dry bulb thermometers unsatisfactory for the determination of the hygrometric state of the air, and has designed a dew-point thermometer to serve the purpose. In it he produces the dew-point by the evaporation of ether through which the air is drawn and which is contained in a small silver vessel. The air flow is then reduced until the dew begins to disappear. The mean of the two temperatures is taken as the true dew-point. In his treatment of evaporation at the boiling-point, Professor Hinchley considered the question of heat transmission from one medium through a plate to another medium and referred to the great loss in transmission caused by the presence of films. The heat pump in which the evaporated steam is raised in pressure and temperature by compression, and then used again as heater steam, was not considered to promise any considerable advantage as the turbo-compressor device used in some cases could only have a heat efficiency of 10 per cent. and the injector used in others only about twice that value.

Mr. Parrish asked why the professor used the heat resistivity instead of the conductivity in dealing with the question of heat flow. He desired to emphasise the *obiter dictum* of the lecturer that "An increase in the supply of sceptical and well-trained chemical engineers offers reward to the plant manufacturer and to the plant user as well as an increase in the national well-being." The use of substances to reduce frothing was fairly common, and he sought the views of Dr. Hinchley on the subject of their value.

Mr. Pooley said that the rates of evaporation of liquids at the boiling-point varied in the most remarkable way. He thought that if the heat pump to be efficient must be worked with a limiting temperature range of 5 deg. C., if exhaust steam were in use a 12-effect evaporator would be necessary.

Mr. Malpas wondered if in dealing with the question of crystallisation plant the author had taken account of the losses by conduction and radiation.

Mr. Alliott, in speaking of surface evaporation, referred to the fact that although in some cases frothing took place with the weak liquor, as the density was increased the frothing ceased. He believed that with thorough circulation and higher vacuum much more breaking up of the solution was possible and a higher rate of evaporation obtainable. The use of anti-frothing substances, he found, while they might prevent frothing, introduced other troubles. He referred to the question of the point at which air should be taken out of an evaporator and demonstrated that this should be done at the bottom of the plant.

Dr. Goodwin, of Canada, described a plant where there was a considerable reduction of evaporation through frothing and how the installation of an indicator with tell-tale lamps improved the efficiency. Once the lamps were installed and proclaimed to all the times the plant needed attention, the man in charge did everything possible to reduce the frothing. The use of anti-frothing materials he thought a very vexed question, because in some cases substances which would cause frothing in others prevented its occurrence.

Professor Hinchley, in reply, said that he preferred to speak in terms of resistivity in dealing with heat transmission because it is possible to add the resistances, whereas in speaking in terms of conductivity one had first to find the reciprocals and add them before any knowledge of the heat flow could be deduced. He said he could not see how it was possible for the heat pump to be as efficient as a quadruple effect evaporator. The radiation losses can be calculated by the aid of the equations given in the paper. He agreed with Mr. Alliott that air should be taken out at the bottom of an evaporator as air is always heavier than the same volume of steam at the same temperature.

GLYCERIN DISTILLATION.

Glycerin is obtained on a large scale in the many saponification processes practised in candle and soap works. In the stearine, candle and soap

industries, glycerin is obtained as a dilute water solution containing also various impurities, the nature of which depends on the processes of manufacture.

A paper on "The Historical Development of the Distillation of Glycerin" was read by Mr. T. H. Gray, technical chemist to Messrs. Gerard Brothers, of Nottingham.

The gradual progress made in the design of glycerin plant was traced from the year 1779, when Scheele produced "the sweet principle of fats" by digesting lead oxide with olive oil, until recent times when so much plant has been installed to manufacture the glycerin necessary for the production of explosives required for the European War. The greatest step in the way of increased efficiency seems to have been the discovery of G. F. Wilson of Price's Candle Company, when he distilled the liquors produced in candle works. The method he introduced of heating the liquors in copper stills and condensing with air cooling was in use, though inefficient, until the introduction of the modern steam heated vacuum stills. Van Ruymbeke, a Belgian chemist, introduced the system in 1893, in which a high-pressure steam coil is used to heat the still and superseded the old direct fire. In this process a high vacuum was maintained, and some steam which would be superheated was introduced into the still. Such plants have been installed during recent years and have given a yield as high as 98·6 per cent. Other processes described were those of Scott, Garrigues and Wood. In Scott's system use is made of steam heating and heat from a flue which is well away from direct flame action. The furnace is used to superheat the steam which is employed in the process. Garrigues employs a combined condenser and superheater, while in Wood's system from one to six stills are worked with a single steam jet. The glycerin vapour carried by the free steam is condensed, while the water vapour passes through a part of the tube system which is hot enough to convert it into steam for another still. Two or even three distillations are used to produce chemically pure glycerin.

Mr. Pooley asked for further enlightenment about the experience of the author on the question of whether the chlorides came over with the glycerin by entrainment or by sublimation. He regarded the question of fuel economy as of very small account in a distillation process of this character where the finished product is so valuable.

Mr. Parrish thought that heating by means of hot oil might be more capable of maintaining steady temperature conditions than the method used.

Professor Hinchley would have liked, if the practical points could have been expanded. When such a high vacuum is used, he did not clearly understand the reason for the introduction of superheated steam. He asked if it was a case of supplying heat or a process of wet distillation.

In reply, Mr. Gray agreed that the fuel consumption was not relatively so important as in some of the cases which were referred to in connection with the other papers. He stated that the fuel used was under 1 ton of coal per ton of crude glycerin produced. This figure does not include the steam used for concentration. The amount of chloride coming over to the condensers is very small, the content being only 0·02 per cent. and he thought it might be due to entrainment. The system of heating employed, hot air, provided the requisite steadiness of conditions. The steam injected into the stills is a necessary part of the process of ordinary manufacture, although glycerin could be produced without steam if a pressure of 2 mm. mercury column was in use.

The meeting was closed with the customary votes of thanks.

During the week-end there were excursions to Loch Lomond, the Trossachs and Edinburgh, as well as a visit to Messrs. Nobel's Explosive Works at Ardeer, where there was a display of the use of explosives in making trenches, demolishing buildings, and of the control of explosive actions.

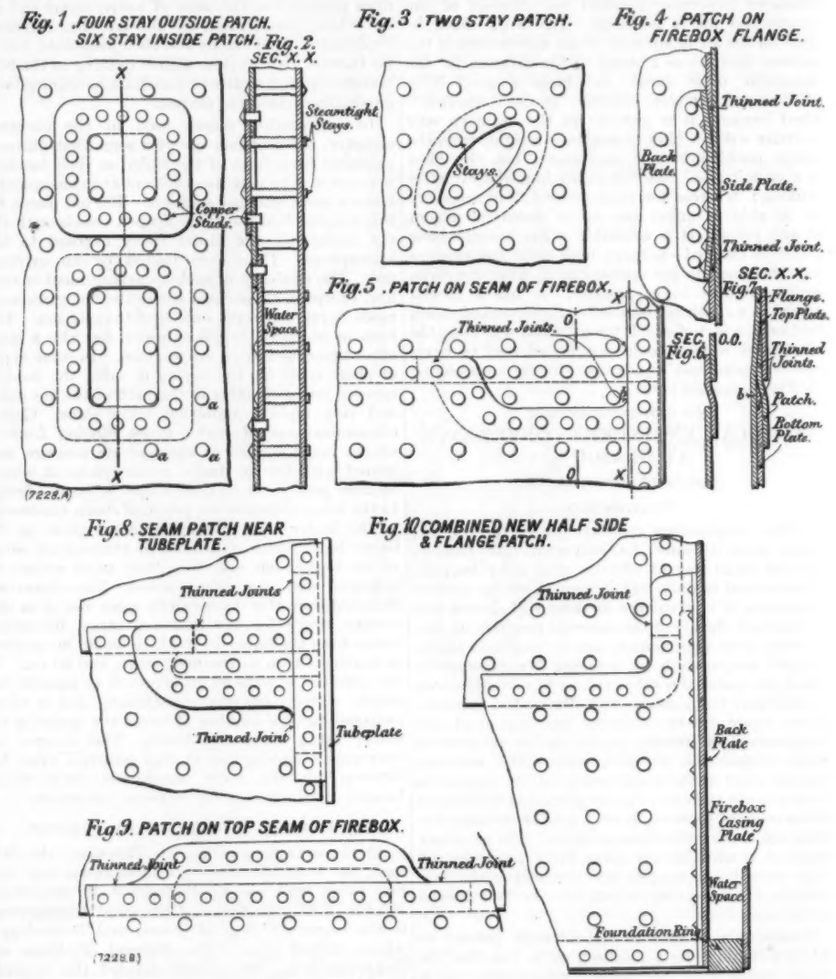
The conference was successfully organised by the Scottish Section, whose chairman, Mr. J. H. Young, M.Sc., and honorary secretary, Dr. John A. Cranston, are to be congratulated on the manner in which they carried through their many exacting duties.

PATCHING OF LOCOMOTIVE BOILERS.

By A. WRENCH, M.I.Loco.E.

PATCHING is extensively employed in the repair of locomotive boilers. This is brought about by the defects which occur in the fire-box plates and seams. Fire-box patches present many difficulties to the boilermaker owing to the narrow water spaces which in many cases make the water side of the plates inaccessible. This necessitates the use of studs instead of rivets as a method of securing the laps. The most common form of patch is the side-plate patch, which varies in size to cover the defective portion. Such patches are called after the number of stays which they contain, thus 2, 4, 12 and 36 stay patches. Three types of these patches are shown in Figs. 1, 2 and 3. The four-stay patch must be a laid on or outside patch, as must all square patches. The disadvantage of these patches lies in the fact that a large seam is exposed to the flame, and pressure tends to force the patch off. This is not the case where the patch is inserted through the hole into the water space. The pressure on these tends to make a good joint. The six-stay and two-stay patches shown in Figs. 1 and 3 are of this latter kind. It will be noticed that the studs with which the patches are secured to the fire-box are between the rows of stays. This method has been found to make a better joint than when the seam is made between the stays, as stays in the seam of a patch tend to restrict breathing and cause leakages. The two-stay patch has two stays in the lap and is of irregular shape. This enables the patch to be passed through the hole and into the water space. It is necessary when inserting patches to remove three stays from near the bottom of the patch to allow it to be turned after it has been passed into the water space. These stays are marked *a* in Fig. 1. When using the outside patch this is, of course, not necessary. The marking-off of the holes in these patches is mostly done from standard templates. The stud holes should be marked so as not to be in line with the stays; this reduces the tendency to crack from stud to stay hole.

An accumulation of dirt in the water spaces as shown in Fig. 11 is often found in locomotive boilers, and if neglected will allow the plates to burn and necessitate a patch. Cracks from stay holes and corrosion round stay heads (Fig. 12) are also repaired by patching. Seam and flange patches are often used in the repair of locomotive fire-boxes, and are more difficult to fit than the side-plate patches.



The method of fitting usually involves the use of thinned joints.

The flange patch, Fig. 4, is used to repair flanges which have cracked in the root or bend. The cracked portion is cut away and also a portion of the flange is removed. The joints are then thinned and made ready to receive the patch. The patch is placed in position, and the holes marked off by the trammel method. This method of marking off is explained by sketches 18 and 19. Centred pegs are inserted in the holes prior to the patch being placed in position, and points marked in two places on the fire-box side. The patch is then fixed with a screw and pipe, and the position of the holes marked from the two corresponding places on the fire-box side. This method of marking-off is adopted on all laid-on seam patches where the water space does not permit the use of a scriber.

Fig. 5 shows a patch used to renew a portion of the lap of a seam which is found to be wasted and badly cracked. This patch has one seam inserted in the water space while the other is on the fire side of the plate. This is necessary as the position of the patch shown in the illustration is near the fire-hole

flange and in a position where it is in contact with the flame. Thinning of joints is employed to enable the patch to fit properly. The thinning of the joint marked *b*, Fig. 5, is very difficult, as this work has to be done under the flange of the fire-door plate, To enable this to be done this flange is lifted by a wedge after several rivets have been removed. This patch forms a good repair and gives very little trouble from leakage in service. A similar patch to this one is shown in Fig. 8, but this is an outside patch, the two thinned joints of the patch being passed under the flange. This type of patch is usually employed on the seam near the tube plate, and being well away from the fire gives satisfaction during working.

Frequently when a fire-box has been working for some years it is found advisable to renew the bottom half of the side plates. In addition to this, the flanges may need patching. It is the practice of some firms to fit new half-sides and then patch the flanges. Fig. 10 shows a combined half-side and flange patch. It will be noticed that the flange is transferred from the side plate to the back plate, a row of rivets being dispensed with. The top of the new flange must extend above the half side seam to enable a good-shaped thinned joint to be made. This method of repair is considerably cheaper than the fitting of a flange patch separately, and is quite satisfactory in service. Cracks, such as shown in Fig. 14, which occur above the side plate seam which are due to the upward expansion of the fire-box, are repaired by a patch inserted under the lap, the cracked portions having previously been cut away. Such a patch is shown in Fig. 9. Grooving near the foundation ring and cracked outer firehole plates are repairable by patching.

Figs. 16 and 17 show a defect of smoke-box tube-plate caused by leakage from the hand hole. This is repairable by a patch which should be made of copper to enable it to be properly fitted on to the wasted portion. The writer once fitted a steel patch on a tube-plate similar to the one shown, and had considerable difficulty in making a proper fit. The patch had to be bolted up several times while hot, and some of the holes were drawn out of truth. This drawing was allowed for by drilling the holes small, but this necessitated the use of bolts of small diameter and little drawing power. Inserting and screwing up bolts in a hot patch is difficult, and the patch cools considerably before the hammer can be applied to do the necessary bedding-on. Filling the corroded portions with cement or red lead is not to be recommended. The throat plates of some types of boilers crack on the shoulders, and boilers fitted with Belpaire fire-boxes develop corrosive grooving at the junction of the throat plate with the barrel at the top. These two defects have been successfully patched, and new boilers are now built with extension plates to cover each of these two places. This practice stiffens the boiler at the top and delays the time when a patch will be necessary.

When the bottom of a locomotive boiler becomes

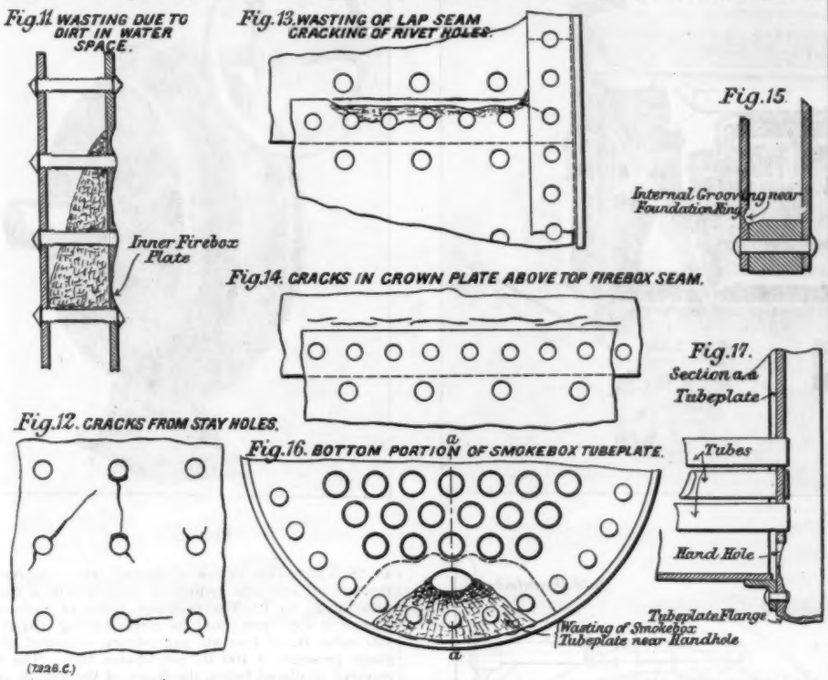
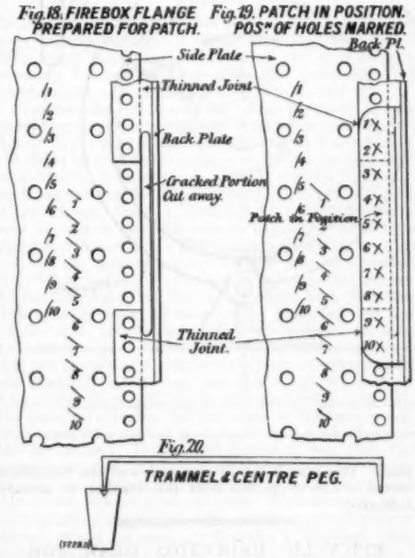


Fig.11. WASTING DUE TO DIRT IN WATER SPACE.
Inner Firebox Plate
Fig.13. WASTING OF LAP SEAM CRACKING OF RIVET HOLES.
Fig.15.
Internal Grooving near Foundation Ring
Fig.14. CRACKS IN CROWN PLATE ABOVE TOP FIREBOX SEAM.
Fig.12. CRACKS FROM STAY HOLES.
Fig.16. BOTTOM PORTION OF SMOKEBOX TUBEPLATE.
Fig.17. Section a-a Tubeplate
Tubes
Hand Hole
Tubeplate Flange
Wasting of Smokebox Tubeplate near Handhole
a
(7226.C.)



corroded, patching, when properly designed, makes a good repair. It is not always recognised that the riveting of a "barrel" patch in a longitudinal direction should be equal in strength to that of the longitudinal joint. Many of these patches are merely single riveted with a narrow pitch of rivets. Considering that these patches are cover patches, a narrow pitch of rivets is not necessary and an efficiency of plate section should be maintained equal to that of the longitudinal joint. When designing the rivet section to be used in these patches the tenacity of the corroded plate may be considered, as, unlike the longitudinal joint, the boiler plate underneath the patch would have to break before the rivets could shear. "Barrel" patches are usually goggled to fit over the circumferential seam, the seam being chipped near the seams of the patch to make a good fit. If any space then occurs between the plate and the patch a wedge is driven in and caulked. It will be seen from the foregoing remarks that repairing boilers by patching is an important branch of boiler maintenance which should be studied by those responsible for the safety of steam boilers. Inspectors occasionally find that the strength of a boiler has been much reduced by improper patching, and several explosions have been found to be due to this cause.

5-TON OVERHEAD MAGNET-LIFTING CRANE.

A TYPE of overhead travelling crane which is eminently suitable for steel works, stock yards and loading banks, is illustrated on Plate IX, published with this week's issue of ENGINEERING. This crane which has a capacity of 5 tons, while the span is 65 ft., has been constructed by Messrs. Sir William Arrol and Co., Limited, at their works at Parkhead, Glasgow, for Messrs. Baldwins, Limited, Swansea. The crane is fitted with a mast working in a lattice frame hung from the crab, while to the lower end of the mast is fixed a cross-beam furnished with three lifting magnets. The latter are fitted with mobile fingers specially designed to secure effective contact with irregular surfaces, such as rail profiles, &c., while the magnets are also mounted so that their distance apart may be adjusted to suit different lengths of stock. The height of lift is 18 ft. The gantry gives a height of rail level of 42 ft. 6 in. above the floor, for the crane runway.

The crane girders are of the lattice type, with auxiliary lattice girders to carry the platform and travelling gear. Horizontal bracing provided between each pair of girders ensures lateral stiffness. The end carriages are built of rolled-steel sections with strong diaphragm plates and large gussets. The crab frame is of rolled steel sections and plates, well gusseted. Attached to the underside of the crab is the lattice frame housing the mast, and on one side of this frame is arranged the operator's cabin. The lifting mast is hoisted up inside the lattice frame, by means of ropes passing over two sheaves. The cross-beam fixed to the mast is composed of steel sections, and forms a double braced lattice cantilever. The lower boom provides a runway for the two trolleys, on which the outer lifting magnets are mounted. These trolleys are fitted with extension pieces with a view to increasing the range of the magnets. Locking gear is provided to keep the trolleys in position.

The crane is worked with continuous current at 220 volts. For the 5-ton load a 60-b.h.p. hoisting motor is provided, running at 630 r.p.m., and giving a hoisting speed of 35 ft. per minute. The traversing motor for the crab is of 15 brake horse-power, and runs at 540 r.p.m. The traversing speed is 200 ft. per minute. The slewing motor is of 5 brake horse-power and runs at 780 r.p.m., at which speed the mast and beam make 3 r.p.m. The travelling speed of the crane on the gantry is 350 ft. per minute. The travelling motor is of 60 brake horse-power, running at 630 r.p.m. The main girder end frames are each provided with two wheels, two of the four carrying-wheels being fitted with spur rings, meshing with pinions keyed to a shaft extending across the crane between the two carriages. This shaft is driven through single reduction gearing by a motor arranged in a house in the centre of the span. An automatic solenoid brake is fitted to this motor. The crab is traversed by the 15 brake horse-power motor, also fitted with an automatic solenoid brake on the spindle, through double-reduction gearing. The load is taken on four falls of plough-steel wire rope, winding two parts on to a cast-iron drum, driven by the 60 brake horse-power motor through treble-reduction gearing. The drum is turned and grooved, and is of sufficient diameter to take the whole rope at a single lap. Three full coils of rope remain on each end of the drum when the cross-beam is fully lowered out. Springs are fitted between the hoisting rope and the beam to reduce the shock of taking the load, and an automatic solenoid brake capable of sustaining the full load is provided, while dynamic braking control is furnished for lowering. An automatic electric brake is fitted to the motor spindle, arranged in such a way that the brake is released directly the motor is started and applied directly the current is cut off or fails for any reason. The brake is designed so that it produces no bending action on the spindle. The brake straps are of forged steel and the blocks of cast iron lined with Ferodo. A totally-enclosed self-resetting limit switch is fitted to prevent overwinding.

The slewing of the mast and cross-beam is accomplished by the 5-h.p. motor driving, through a pinion on the end of a vertical shaft extending downwards from the crab, a large spur ring, to be seen fitted round the mast at the base of the lattice frame. At its upper end the vertical shaft is fitted with a worm wheel,

EPICYCLIC REDUCTION GEAR FOR PORTABLE AIR COMPRESSOR.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

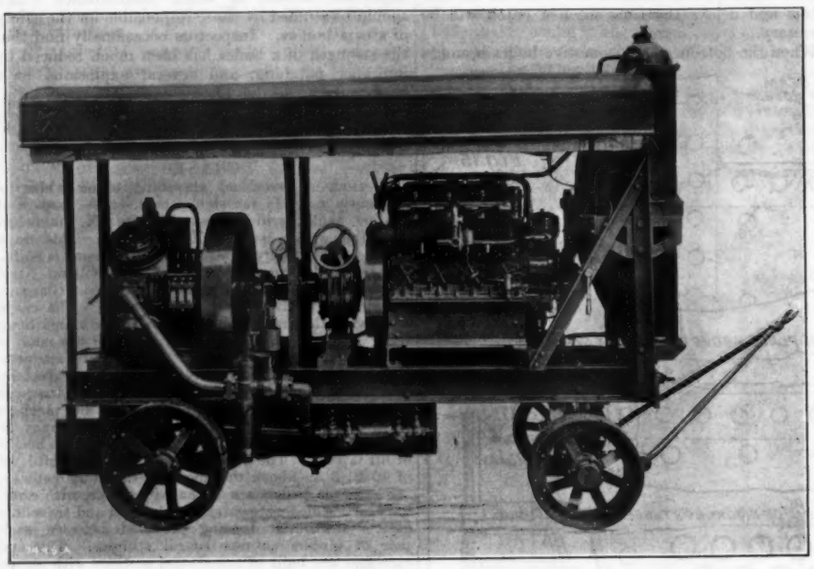


FIG. 1.

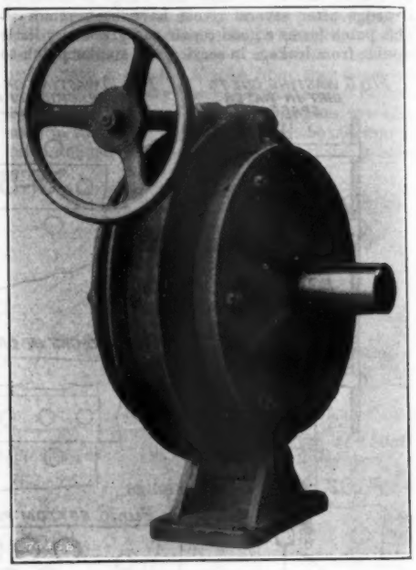
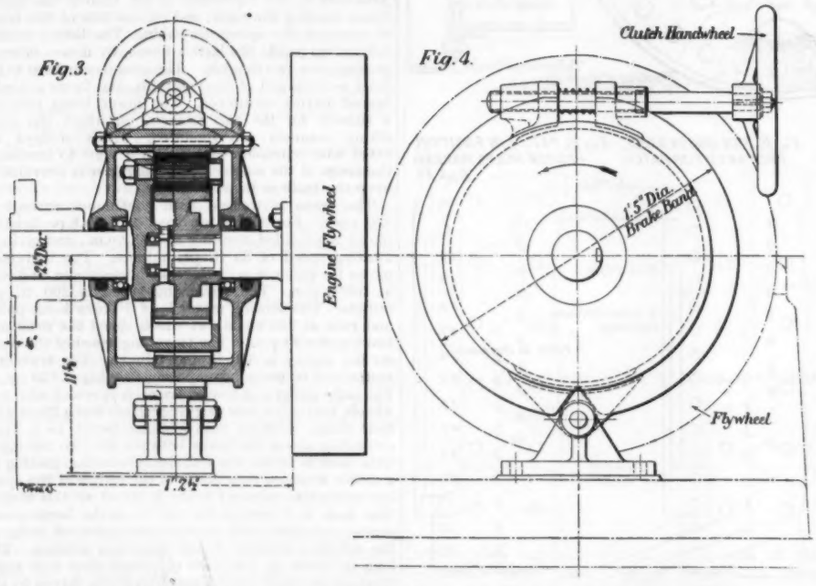


FIG. 2.



driven by worm coupled to the motor spindle. A friction clutch is incorporated in this motion, so that in the event of excessive shock, sufficient slip would be allowed to prevent damage to the gearing. The motor spindle is fitted with an automatic solenoid brake. The worm gear and wheel are enclosed in an oil bath, and the worm is fitted with a ball thrust bearing.

The operator's cabin is arranged with large windows, with the control gear in a convenient position. The controllers for the hoisting and travelling motion are of the contractor type operated through master controllers. The slewing and traversing motors are operated by means of drum-type controllers. Resistances throughout are of the five-minute protected type. The switch board consists of a slate panel with one double pole main contractor-type circuit breaker, one single pole relay for each motor circuit, and one in common return, one pilot lamp, one plug and socket for flexible cable for lamp, and switches, &c., for lamps.

The four motors are of the totally enclosed series reversing type, rated for a temperature rise not to exceed 90 deg. F., after one half-hour's run at full load. The crab is totally enclosed, and the travelling motor is also protected from the weather, as already indicated.

EPICYCLIC REDUCTION GEAR FOR PORTABLE AIR COMPRESSOR.

WE illustrate by Fig. 1 on this page a portable air compressor of the type which is now being used for supplying compressed air to the pneumatic chisels and hammers employed for street work in London and elsewhere. The particular plant illustrated is, however, intended for the tropics, and is therefore provided with a specially large radiator. This is the more necessary in that it has to cool the water supply to the compressor as well as that to the engine jackets. Air is forced through the radiator by a large belt-driven fan.

The plant has been constructed by the Parsons Motor Company, Limited, of the Town Quay Works, Southampton, and comprises one of their 4-cylinder petrol engines fitted complete with enclosed vertical governor and oil and water pumps, and rated at 28 h.p. This drives a Reavell air compressor through an epicyclic reduction gear, giving a speed ratio of 2½ to 1. The designed speed of the compressor is 450 r.p.m., and its corresponding output is 150 cubic ft. of free air per minute delivered at a gauge pressure of 100 lb. per square inch. The air receiver is placed below the frame of the vehicle and is provided with an unloading valve and four connections for the supply of air to tools. The main novelty embodied in the design is the reduction gear, an external view of which is represented in Fig. 2 and a section and elevation in Figs. 3 and 4. In principle, of course, this type of reduction gear is well known, but since the gear has in the present instance to make long continuous runs at full power, and in important thoroughfares, careful design of details was necessary to ensure endurance and an absence of noise when running. As best seen in Fig. 3, the centre wheel is splined to one end of the engine crankshaft. There are four planet pinions mounted in a steel cage, the pins on which the pinions run being supported at both ends and thus very rigidly secured. The internal wheel or rack is fixed to the housing, which is made in halves and held together by through bolts as shown. Ball bearings are provided where the shafting passes through this housing, as also compressed packings to prevent oil leakage. The housing is turned externally, and this turned surface serves as a seat for the brake bands, which are best seen in Fig. 4. By loosening this brake the engine can be started up light, and then by tightening up the bands by the hand wheel and screw shown the housing is held stationary and the compressor shaft caused to revolve at two-fifths of the engine speed.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—The annual volume of the proceedings of the Institution of Railway Signal Engineers for the year 1921, which has just been published, comprises a good deal of interesting matter. The issue contains three papers dealing with aspects of track circuiting. Single-line token working, and three-position signalling form the subjects of other papers which are fully discussed. In view of the recent report of the Committee appointed by the Ministry of Transport to go into the question of automatic train control, the paper by Mr. W. J. Thorrowgood on this subject will be of considerable interest. In general, however, the discussion on Mr. Thorrowgood's paper did not result in any decisive conclusion. The opinion seemed to be on the whole that practical systems could not be introduced with certainty of success, while opinion was very divided on the question whether the introduction of automatic train control was desirable or financially possible. The figures given by Mr. Thorrowgood are in approximate agreement with those in the Committee's report. It was pointed out that while methods of working were already good, the expense of trying to attain to absolute security became enormous.

THE TWIN-SCREW STEAMSHIP "GOUVERNEUR-GENERAL CHANZY."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

(*For Description, see Page* 108.)

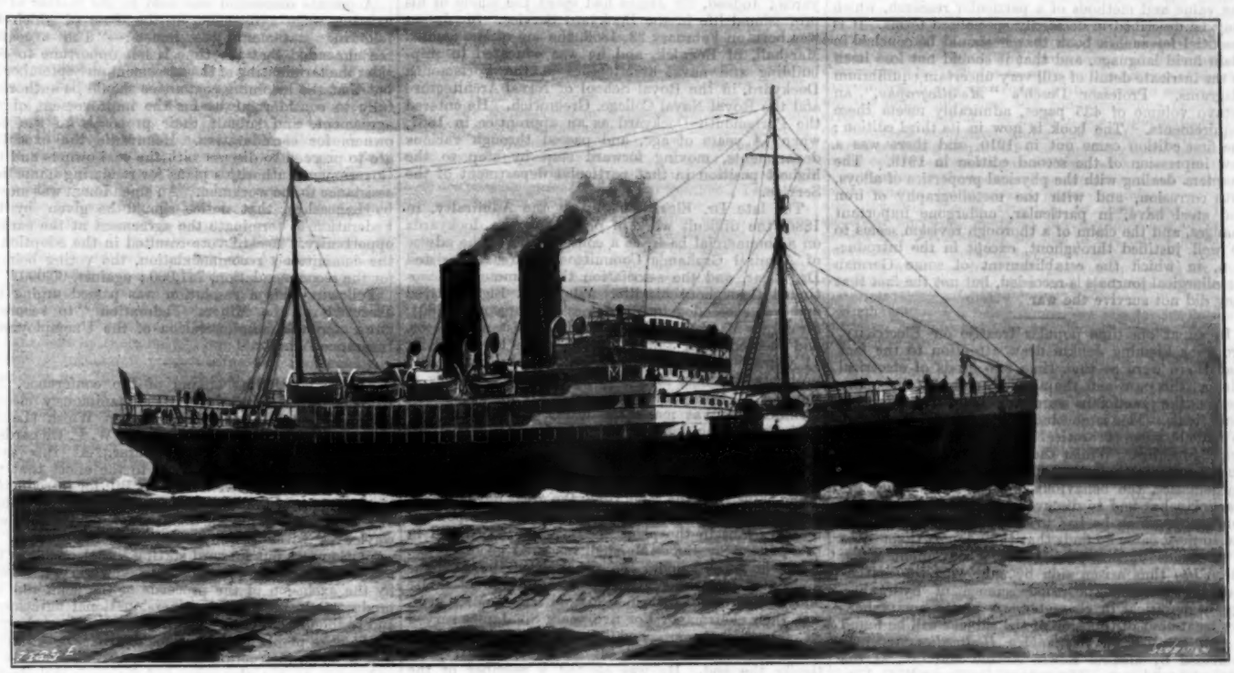


FIG. 1.

NOTES ON NEW BOOKS.

PROGRESS in the constructive efficiency of refrigerating machinery has been markedly rapid during the last few years, and the processes of mechanical cooling originally confined almost exclusively to the brewing industry, have found a greatly extended application. Naturally the literature of the subject has increased proportionately, and the appointment of professors in universities to direct studies and promote research has added not a little to this increase. The latest contribution comes from Professor H. I. Mackintyre of the University of Illinois, who in his "*Principles of Mechanical Refrigeration*" (McGraw-Hill Book Company, Inc., New York and London; price 12*s.* 6*d.* net) makes an interesting and valuable addition to the discussion of the technical details and the manipulation of machinery employed. The reversed heat engine cycle can be presented mathematically without much difficulty, but the author has preferred to rest his explanation on analogies drawn from steam machinery and steam cycles. This book being written for Americans, the authors description of machinery applies rather to the use of ammonia as a refrigerant, since that substance is most generally in use in the States. It has many recommendations, and not a few drawbacks, but especially ammonia has a convenient range of vapour pressure throughout the range of temperature encountered in practical refrigeration. From the thermodynamic point of view, ammonia admits of very efficient working and where the chief factor in determining the choice of a refrigerent is the economy of power, it has no rival. On the other hand, its action on copper and brass is detrimental, and serious results may follow from accidents. Extraordinary precautions have to be taken to prevent leakage, and secure tightness of joints, and the author rightly insists on a far higher standard of accuracy in the fittings than would be necessary in the case of steam. Carbon dioxide is generally preferred in this country for the vapour compressing refrigerating machine, probably on account of greater safety in use, though thermodynamically it is not so efficient as ammonia. Professor Mackintyre states that during the war, CO_2 gained some popularity in America, especially for marine installations, and that the future will see a great advance in its use. Other refrigerants, as sulphurous acid, ethyl chloride, and methyl chloride are practically limited in use to small plants, and are not elaborately discussed here. Similarly the original form of machine which used air, cooling it by means of expansion in a cylinder in which it does work against a piston are now neglected, though it should be remembered gratefully, that these machines created the cold storage industry by rendering possible the conveyance of mechanically refrigerated cargoes from distant ports.

Another class of machines, which the author well describes, are the so-called "absorption machines" where, in the case of ammonia the vapour is alternately dissolved by cold water under a relatively low pressure, and distilled from solution in water under a relatively high pressure by the action of heat. Anhydrous liquid ammonia can thus be obtained at a high pressure, and allowed to pass through an expansion valve into an evaporator, where a low pressure is maintained by causing the escaped vapour to pass into an absorber where it is dissolved in cold water, which in its turn can be heated to give off the vapour under high pressure. The crude process has been greatly improved, but the author does not discuss any of the suggestions that have been made. The methods employed in ice making, and the descriptions of the applications of refrigeration are distinctly interesting, the author showing himself here as elsewhere particularly well qualified to deal with the practical side, but the usefulness of the book would have been increased if more space had been given to the theoretical. It is to be regretted, too, that the recommendation of Sir Alfred Ewing's Committee to express the refrigeration produced in terms of calories per second has not been adopted. This seems to be a very practical suggestion, while a unit of one calorie per second might be used to describe a standard class of machine.

The increasing importance of jig work is being realised by the increase in the numbers of those who write on the subject. An excellent book has just been devoted to it, namely, *Jigs, Tools and Fixtures*, by Philip Gates (Crosby Lockwood and Son. Price 8*s.* 6*d.* net). A very large amount of valuable information is compressed into 195 pages, with 165 illustrations, comprising chiefly good line drawings and sections, with a sprinkling of photographs. No apology is needed for prefacing the volume with an account of the conventional features that characterise all shop drawings, nor of the utilities of hand sketching. Chapter III.—First considerations in design—gives a lucid epitome of the essentials that must underlie all jigs and fixtures—that which relates to the limitation of the number of movements of the operator, the sequence of operations, the relative cost, the quality of the product, weight, single or multiple equipment, and the question that so often arises, that of modifying the design of an article to facilitate jigging. A lengthy chapter on drill jigs goes very thoroughly into the methods of locating various forms of components that have to be drilled. Different types of clamps are illustrated, a selection of jigs, including an example of indexing, and a multiple spindle head. Sizes for standard bushes are given later in the work. Chapter V. —Milling fixtures—illustrates the different kinds of milling methods, corresponding with the shapes and dispositions of cutters, with examples of "string," and indexing fixtures. The chapter on chucks and turning equipment, illustrates several forms of expanding mandrels, spring collets, turning fixtures, tool holders for the cross slides of turret lathes, and tools held in turrets. Chapter VII., on cutters, describes the typical forms of mills, of reamers, boring tools, counterbores, and allied forms, and broaches. Screwing equipment is the subject of the next chapter—Dies, taps and chasers. A chapter is devoted to the subject of gauges, their limits and their principal forms. Another deals with press tools, blanking, and multiple tools, punches, bolsters, strippers, stops, and combination tools. Chapter XI. treats of the design of Brown and Sharpe cams for automatics. Chapter XIII., on jig and tool office procedure, deals with the methods of carrying the work through—the drawings and their details, tracing, filing and recording, and the filling in of operation sheets. The scope of the experience called for in this work is indicated by the formidable list (page 180) of the matters that have to be carefully weighed when preparing a new design for the shops. A chapter on standardisation, and an index conclude this useful volume.

Discoursing recently on the technical control of the iron industry, Professor Tafel, of Breslau, remarked that, out of three metallurgical students, two went into the works, whilst the third sought employment in the metallographical and chemical laboratories. That specialisation is both indispensable and advantageous. But the man who goes straight to the works ought to understand what the test sheets coming from the laboratories signify, and the man who analyses and tests should certainly be well acquainted with the manner in which his materials have been produced. Metallography, the study of metals and alloys by physical and microscopical methods, is a relatively new science, which has already developed

into a distinct branch of physical chemistry. The practical man cannot keep abreast of that development, but books like "*Metallography*," by so competent and conscientious an author as Professor Cecil H. Desch, D.Sc., of Sheffield [Textbooks of Physical Chemistry; London: Longmans, Green and Co., 16*s.* net] will help him to follow the drift of the science, and to understand the value and methods of a particular research, which may be described in decidedly specialised terms. It is essential for such a book that it should be couched in plain lucid language, and that it should not lose itself in the intricate detail of still very uncertain equilibrium diagrams. Professor Desch's "*Metallography*," an octavo volume of 435 pages, admirably meets these requirements. The book is now in its third edition; the first edition came out in 1910, and there was a new impression of the second edition in 1918. The chapters dealing with the physical properties of alloys, with corrosion, and with the metallography of iron and steel have, in particular, undergone important changes, and the claim of a thorough revision seems to be well justified throughout, except in the introduction, in which the establishment of some German metallurgical journals is recorded, but not the fact that they did not survive the war.

In an at one-time popular treatise on Electricity, Professor Fleming Jenkin drew attention to the fact that there were at that time two kinds of electrical science, the pure and the applied, and that in many respects the practicians were more truly scientific than their rivals. The same kind of distinction might well be made between theoretical hydro-mechanics and practical hydraulics. Whilst those engaged in the former study, can in the more simple cases determine by mathematics, the behaviour of their ideal fluid, the practician has had to discover by experience how the fluids with which he has to deal actually do behave, and in most cases he finds that they deport themselves in all kinds of unexpected and inconvenient ways. There has thus arisen side by side with the mathematical theory, a practical science of hydraulics, largely empirical in character. A pretty comprehensive treatment of this side of the subject will be found in the treatise on *Elementary Hydraulics*, recently published by Messrs. Edwin Arnold and Co., at the price of 7*s.* 6*d.* net. The author, Professor F. C. Lea, states in his preface that he has had specially in view the needs of evening and day technical schools. The book is very fully illustrated, and as already stated, pretty well covers the field of practical applications, whilst a well-selected series of examples at the end of each chapter will enable the student to test his progress. The traditional discussion of the loss at the sudden enlargement of a channel should, however, not have been reproduced without the warning that the conclusions reached were seldom verified in practical experience, which has shown, for example, that by turning "water grooves" on an air pump bucket, the leakage past the bucket is increased and not diminished as the theory given apparently indicates. The traditional illustration of the character of the flow just beyond the enlargement is also reproduced, and unless specially cautioned, the student is very likely indeed to get the idea that the whole space outside the main flow is filled with vortices, a condition which both theory and experience shows to be impossible. A stationary vortex cannot be maintained in the immediate neighbourhood of a solid wall. Under the influence of its "mirror image," it would immediately move away, but in actual practice it appears, instead, to break up in its very birth throes, so that we get a surface of discontinuity between the moving and the dead water, and the latter is accordingly the seat of very little energy loss. From one point of view, the difficulty of transferring energy from the moving fluid to "dead water" is very unfortunate, as it is this which is mainly responsible for the gross inefficiency of the steam jets used as vacuum augmenters. In a second edition of the work, we think the author ought to direct attention to the prime importance of Reynold's function $\frac{v}{dv}$, which does not appear to be even mentioned. The time is bound to come, and the sooner the better, when even elementary classes will be introduced to the theory of dimensions, of the utility of which the above function affords a striking example. The need is the more pressing as students working in laboratories are encouraged to find empirical expressions to represent their observations. It very frequently happens, that the formulas thus found are dimensionally irrational, and accordingly quite inapplicable outside of the range actually covered by the experiments.

MOTORS FOR USE IN COAL MINES.—In the course of the investigation of permissible motors for use in coal mines, being conducted at the Pittsburgh, Pa., experiment station of the Bureau of Mines, tests have resulted in the conclusion that gasoline is more sensitive to ignition than methane.

THE LATE SIR JAMES MARSHALL, K.C.B.

BY the death, at his residence at Southsea, on the 21st inst., of Sir James Brown Marshall, K.C.B., there has passed away a naval architect who, for nearly 50 years, has been closely identified with warship building and the development of the Royal Dockyards; indeed, Sir James had spent the whole of his professional life in the Dockyard Service. Sir James was born on February 23, 1853, the son of Mr. Samuel Marshall, of Berwick, and he was educated in shipbuilding and naval architecture at the Portsmouth Dockyard, in the Royal School of Naval Architecture and the Royal Naval College, Greenwich. He entered the Portsmouth Dockyard as an apprentice in 1867, when 14 years of age, and passed through various departments, moving forward step by step to the highest position in that particular department of the Service.

The late Dr. Elgar took up at the Admiralty, in 1886, the difficult work of organising the dockyards on a commercial basis, as a consequence of the advice of Admiral Graham's Committee. Marshall assisted Dr. Elgar, and the association thus commenced continued throughout his life. When Dr. Elgar retired and was succeeded by Sir James Williamson in 1891, Sir James Marshall still continued as assistant director, and succeeded Sir James Williamson in 1906, and for 11 years he occupied that office, namely, until 1917, probably the most strenuous period in the history of the Royal Dockyards. The practice of appointing technical men as managers of the shipbuilding and engine repairing departments was thoroughly justified during his time, because an enormous amount of work had to be undertaken, not so much for the building of new ships, but for the repair and re-conditioning of existing ships. At the same time, the great development in the type of ship for the Navy required important modifications in the plant and machine tools, and in this matter Sir James Marshall rendered good service. When he retired under the age limit in 1907, he was invited to join the board of Messrs. J. Samuel White and Co., of Cowes, of which his old friend, Mr. Carnt, was then chairman. For five years Sir James served as deputy-chairman, and afterwards succeeded as chairman. He continued his association until practically the end. He was elected a member of the Institution of Naval Architects in 1886, and served for several years on the Council from 1906, but he took little part in public life. He married Alice, eldest daughter of the late Joseph Pharaoh, Bedhampton, by whom he is survived, and the sympathy of many professional and other friends goes out to her in her bereavement.

INDUSTRIAL NOTES.

THE ballot of the engineering trade unions mentioned in a former issue, page 41 *ante*, shows a majority against acceptance of the employers' terms for the withdrawal of 16*s.* 6*d.*, part of the war bonus. There voted 70,901 against the reduction, and 43,937 for it, a majority against of 26,964. The figures taken separately are as follows:—Amalgamated Engineering Union—against, 43,581; for, 24,531; National Union of Foundry Workers—4,385 against; for, 4,192; National Federation of General Workers—against, 22,105; for, 14,816; Operative Spindle and Flyer Makers—583 against; 136 for; Amalgamated Machine, Engine and Iron Grinders and Glaziers' Society—against, 174; for, 227; Operative Mule and Ring Spindle Makers—against, 73; for 35. As is usually the case, very few men seem to have taken the trouble to vote. At the time of going to press, conferences were being held by representatives of both sides. A separate vote on the same point is being taken in the shipbuilding trade unions, and the result is to be announced to-day.

The port employers throughout the country are proposing to make a further reduction of 2*s.* per day in dockers' wages, to bring the minimum daily rate down to 10*s.*, instead of 16*s.*, awarded by the Shaw report. A proportional reduction would also be made in piecework rates, since the employers' claim that these, in some ports, are yielding unduly high results, as compared with day rates.

A conference of the Miners' Federation was held last week in Blackpool, when a number of different subjects were dealt with. A resolution was passed claiming compensation for total incapacity equal to the pre-accident weekly wage, or average earnings, and payment of 500*l.* to the widow in case of fatal accident. It was decided further, and by a two to one majority, to protest against the Daylight Saving Act and to seek its repeal. One of the miners' objections to the Act was that daylight saving, since it meant shortening the production of artificial light, meant therefore a decrease in the use of coal, and it was advisable to pass resolutions in the interests of the craft and the burning of more coal. Another resolution was passed on the right of the miners to a minimum wage; whilst one to the effect that the Miners' Federation be urged to affiliate and actively identifying itself with the Third International was defeated by 883 votes to 118, each vote representing 1,000 members, only South Wales voting for the resolution.

A private discussion was held in the matter of the existing wage agreement, at the close of which the following statement was issued:—"The executive recommended that the time is not opportune to consider the terminating of the agreement on September 30, but that the incoming committee should be authorised fully to consider means for the improvement of the agreement, and submit their proposals to the coal owners for consideration. Meanwhile the executive are to proceed to discuss with the coal owners and the Government authorities plans for rendering immediate assistance to the workmen. An amendment was moved by Lancashire that notice should be given by the Federation to terminate the agreement at the earliest opportunity. A card vote resulted in the adoption of the committee's recommendation, the voting being—for the recommendation, 741,000; against, 90,000."

Following this a resolution was passed urging the executive of the Miners' Federation "to secure a more equitable administration of the Unemployment Insurance Acts."

At the concluding sitting of the conference, Mr. Herbert Smith (Yorkshire) was unanimously elected president for the year, Mr. Stephen Walsh (Lancashire) was elected vice-president, Mr. W. P. Richardson (Durham) was re-elected treasurer. At this same sitting a resolution was passed to the effect that the executive be instructed to draft a Bill for introduction in the House of Commons by the Federation Members of Parliament seeking the abolition of royalty rents and wayleaves without compensation to the owners. A resolution was put forward stating "that owing to the loss sustained by the miners and cokeworkers generally by the exclusion of the proceeds of the coke and by-product industry in the miners' national agreement, and to the unsatisfactory transfer prices of coal charged to the coke plants in the various districts, it be moved that it be an instruction to the executive committee to endeavour to get the coke and by-product industry included in the next miners' national wages agreement, or, alternatively, to obtain a national wages agreement for the coke and by-products industry." On the suggestion of the chairman this motion stood over until the special conference to be called later, when the Federation would be in a position to discuss the wages question generally.

A statement recently issued by the Mines Department states that the coal mining industry showed a profit of 717,353*l.* for the quarter ended December 31 last, made up as follows:—The total tonnage raised amounted to 55,033,074 tons, and the net costs of production of the 49,634,464 tons which were "disposable commercially" worked out at 56,366,272*l.*, or 22*s.* 8·55*d.* per ton. Commercial disposals realised 57,083,625*l.*, or 23*s.* 0·02*d.* per ton, showing the said credit balance of 717,353*l.*, or 3·47*d.* per ton.

The printing trade in the provinces is disorganised owing to the rejection by the Typographical Association of the decision arrived at by the Industrial Court in regard to a reduction in wages, referred to on pages 23 and 41 *ante*. Other printing trade unions have come to terms with the employers, and a number of members of the Typographical Association have also accepted the wage reduction.

Industrial concerns on the Continent are on the whole utterly dissatisfied with the compulsory working of the eight-hour day, and in one country (Switzerland) they have decided to discontinue it for a period of three years. The Swedish Union of Employers denounce it as a great calamity for the industry. The eight-hour day measure, they contend, has put the industry in a straight-jacket, in which it lacks the freedom necessary for development, and the favourable social effects which were to result from it have not materialised. There is no increased intensity in working, but the cost of production, owing to the introduction of the eight-hour day, has risen in almost every case—in the printing paper industry by 8·4 per cent., in the fine paper industry by 11 per cent., in the wood pulp industry by 15 per cent., and in many other industries by 15 per cent. to 20 per cent. The men are not using their increased leisure to advantage. In Denmark also there are loud complaints concerning the effects of the eight-hour day. In Switzerland the Legislature has added the following clause to the Factory Act: "During comprehensive and serious economic crises the ordinary working hours can be increased to 54 per week. The daily hours must in no case exceed 10 hours." The authorities decide

whether conditions warranting the change exist. When the above conditions (general economic crises) do not prevail the Legislature can allow the weekly hours to be increased to 54 for whole branches of industry or isolated factories. This Act, as above stated, is to stand for a period of three years.

Dr. James P. Day, President of Syracuse University, United States, writing to the *New York Times*, says it is a favourite contention with champions of labour unions that all men who oppose the practices of the unions are enemies of labouring men and friends of capitalists. The unions have acquired limitless power out of the daily wage of the members. Does anyone imagine, asks Dr. Day, that but for the enormous revenue thus secured, the leaders would take such an intense interest in pushing up wages without regard to the economic effect upon the business of the country? The labour union, which might have been of immense service to the country and to the working men who belong to it, has been made a curse to both the land and the working men. It has denationalised its members and has burdened and oppressed the greater numbers who would not join it. The safety of a country is in the intelligence of its working men. There are some very ignorant men in the unions, and these men are the hope of those who control them. They hold their leadership by them, and by them only. But there are increasing numbers of intelligent press-reading and book-reading union men, and there are signs that such men do their own thinking and cannot be driven like cattle. The trade union can be made as self-contained, self-respecting and self-controlled as the Masonic order, the Odd Fellows, the Citizens' Club, or the Chamber of Commerce. No more than do these great organisations, does it require loud, open-mouthed champions to bellow riotous threats throughout the land. Dr. Day adds that capital and labour work together harmoniously when left to their own problems, undisturbed by the demagogues. They are Siamese Twins in their sympathetic relations, joined by an indissoluble bond; if one were to die, the other must die also.

The Secretary of the London Iron and Steel Exchange, Limited, in his report on the weekly meeting of last Tuesday, states that the trade holidays are now in progress and many of the consuming works are shut down until the beginning of August. It is generally anticipated that when work is resumed, business will show an immediate expansion, and this view finds support from the number of inquiries, particularly for semi-finished material, that have been circulated lately. Some of the lower-priced Continental quotations have been withdrawn, and British works have expressed their intention of meeting foreign competition and have so far succeeded in taking most of the business that has passed in the home market. The modern Lincolnshire works have been conspicuous in this respect, and most of the recent orders for pig-iron for America have been secured by them in the face of efforts by Continental producers to obtain a share. Fresh orders from the United States are under negotiation, but have not yet been placed. The market for billets and sheet bars is the most active, and this reflects the anticipations that are current of a revival in trade in September. These hopes are largely based upon a belief that the good monsoon will lead to extensive purchases by India and also to the fact that conditions on the Continent and in the United States will hamper foreign producers in competing with British works.

THE BRINELL TEST.—The Brinell method for testing the hardness of metals was introduced in 1900, and is now universally accepted, both in the laboratory and in the workshop, as the most accurate and reliable hardness test for all classes of steel and for most of the non-ferrous alloys. This is the statement—a very true one—which opens a small booklet on *The Industrial Application of the Ball Hardness Test*, recently issued at the price of 3*s.* 6*d.* post free, by Messrs. Alfred Herbert, Limited, the well-known engineers of Coventry. It deals in detail with the test in question and with the machines for carrying it out; it contains also Brinell hardness number tables. The information and instructions it contains form a useful contribution on the particular subject.

"THE SHIPPING WORLD YEAR-BOOK, 1922."—This annual for the present year, the thirty-sixth edition, is edited by Mr. J. T. Findlay, and is issued by *The Shipping World* offices, Effingham House, Arundel-street, Strand, W.C.2, at the price of 21*s.* net. It opens with tables of conversion of foreign into British units, explanations of astronomical and other terms, general information, data on freeboard, load lines, a very complete digest of merchant shipping Acts, &c. Then follow port directories, arranged alphabetically of British, Dominion and foreign ports, the information under these headings including the latitude and longitude, trade, accommodation, depth of water, harbour dues, pilotage charges and officials. Half of the book is set apart for the Customs tariffs charged by all nations. The book contains over 2,100 pages of closely, but very clearly-printed data, which will be found of great interest and of much practical value by merchants and shippers.

ROYAL METEOROLOGICAL SOCIETY.

A MEETING of the Society was held on Monday, July 24, in the Rooms of the Royal Society, Edinburgh, Dr. C. Chree, F.R.S., President, in the chair. This was the second meeting to be held in Edinburgh since the amalgamation in January, 1921, of the Scottish Meteorological Society with the Royal Meteorological Society, and it is hoped that further meetings will be held in Scotland from time to time. The following papers were read and discussed, and abstracts of the same are appended:—

1. "*Observations of Upper Cloud Drift as an Aid to Research and to Weather Forecasting.*" By C. K. M. Douglas, B.A. The paper discusses the wind near the top of the troposphere in different stages of the life history of a cyclone, following on recent researches under Professor V. Bjerknes in Norway. The conclusions are based on a large number of observations of high clouds and also on observations by other methods, as far as these are possible in really disturbed weather. The pressure distributions aloft, disclosed by the upper winds, are considered in relation to temperature, as the pressure at considerable heights is largely determined by the temperature of the column of air underneath. The results show that there is a complete lack of symmetry in the temperature distribution over a cyclone in its earlier stages, with a great contrast in the temperature of the whole troposphere between the "polar" and "equatorial" currents. When the cyclone has reached its final stage, in which it normally becomes stationary and fills up, the distribution of temperature and wind in the upper air approaches to symmetry round the centre, and the easterly current on the north side often extends throughout the troposphere. The conclusions in the paper are supported by direct observations of temperature when these are available. With regard to weather forecasting, it is found that no simple rules can be drawn up, as the changes in the wind at considerable heights follow rather than precede those near the surface. Observations of high-cloud motion are, however, a valuable supplement to other information, as they throw light on the temperature distribution in the troposphere as a whole.

2. "*Note on the Effect of a Coast Line on Precipitation.*" By J. S. Dines, M.A. The paper discusses a convergence effect which will be found over a coast line when the wind blows along the coast, the low pressure being over the land. The convergence is due to the greater incurvature which occurs in winds over the land than over the sea. An example is worked out, and it is found that under favourable conditions, an upward current of 15 ft. per minute may be produced over a strip of the earth's surface extending 5 miles on each side of the coast line. An example of precipitation which may have been caused by this effect is given. A somewhat similar effect occurs wherever the pressure gradient varies along a line perpendicular to the isobars and the following rule is deduced:—"In any area where the pressure gradient increases towards the 'High' there will be rising air."

3. "*Note on Turbulence, as Exhibited by Anemometer Records, Smoke and Cloud Formation.*" By A. E. M. Geddes, D.Sc., and G. A. Clarke. The first section of the paper deals with the phenomenon of turbulence and eddy motion. The effect of this eddy motion is shown near the surface by the records from a pressure-tube anemometer. The turbulence and consequent eddy motion are seen to depend largely on the nature of the surface over which the air current is travelling. Especially is this the case in so far as eddies affect the direction of the wind. The presence of eddies higher up is rendered visible by the behaviour of smoke from tall chimneys and by the manner in which this smoke is raised and at the same time dissipated laterally. Higher up, cloud of the stratus order is formed. These smoke eddies and clouds occur when there is little or no convection due to heated air and, therefore, their appearance and formation is evidently in accordance with Taylor's theory of eddy motion. The formation of eddies at the junction of two currents of different temperature and hence of different density is demonstrated by photographs showing the fragments of cloud which form *below* the base of a line squall or similar cloud.

The second section of the paper describes that interesting variety of cloud intermediate between the normal Cirrus and Cirro-cumulus types. The changes that this cloud undergoes have long proved a puzzling phenomenon to cloud observers. The change of the Cirro-cumulus type, which is generally regarded as a water-droplet cloud, into the ice-crystal structure of true Cirrus is only to be expected at the high altitudes, and consequently generally very low temperatures of the levels where this cloud is found, but the great frequency with which the reverse process is to be observed calls for some explanation. A number of lantern slides showing these changes and different varieties of the "Cirro-macula," as the cloud is termed, were shown, and the meeting was invited to offer suggestions upon the point in question.

An exhibition of representative meteorological instruments was on view in the Rooms of the Royal Society.

"THE MOTOR CAR INDEX."—A very useful publication for all who are interested in motor cars in any capacity is the book having the above title. It gives detailed particulars of every make of car, both British and foreign, for the years 1909 to 1922, the information, the bore and stroke, number of cylinders, maker's H.P., arrangement of cylinders, ignition, cooling system and so forth. A separate directory gives the names of the makers, their works or office address, and the British concessionnaires in the case of foreign cars. It can be obtained at the price of 10*s.* 6*d.* from "The Motor Car Index," 31, Essex-street, Strand, W.C.2.

INDUSTRIAL RESEARCH.

THE British Electrical and Allied Industries Research Association report covers the activities of the Association over the last quarter. It has been found advisable to set up two new Committees, whose work shall co-ordinate that of some of the existing Committees. The first will consider the classification of the heat-resisting properties of electrical materials, and a system of nomenclature and test methods for these; the second will deal with the testing of the electric strength of insulating materials. The programme of the latter Committee also includes research on the testing of sheet materials with disc electrodes, with a view to ascertaining the limitations, best test conditions, and probable errors of the method. Samples of the important group of materials comprised under the head of varnished fabrics are being prepared by co-operating manufacturers under controlled working conditions, with a view to the investigation of the technical problems involved in their improvement. Co-operating paper manufacturers are also devoting special attention to their product for electrical purposes, made to the specifications of properties and test-methods set out in the report already published. The working temperature of papers is also receiving attention from the Association. A report on the completed research upon hard composite insulating materials is now available.

Much new work is being done upon oils for insulating purposes. A report has been prepared, after full consideration of the proposals of the American Society of Testing Materials, giving reasons for the Association's preference for sphere gaps for oil tests. Further research, however, is in hand to determine the relative merits of the horizontal and vertical arrangements of sphere gaps. The experiments upon the improvement and maintenance of electric strength by centrifugal separation of the oils, whilst still incomplete, show the method to hold much promise; this conclusion has been reached both from experiments with a De Laval separator and from the study of similar work done in U.S.A. Advantage has been taken of the presence in this country of Mr. Evert Norlin, of the Government Testing Institute of Sweden, to ascertain and discuss the Continental and American opinion of sludge and tar-value determinations. Other qualitative researches upon insulating oils are also in hand.

Tables and an accompanying report are now in preparation showing the experimental conclusions arrived at concerning the safe loading of British Standard Cables up to 11,000 volts; tables for higher voltages await the results of investigations on dielectric losses. A satisfactory method has been found of applying results obtained on single-core cables to three-core cables. Other reports on cables, due shortly, deal with the effect of grouping and the intermittent loading of cables. The researches for determining under working conditions the elastic modulus and other physical properties of wires and cables of a variety of metals in ordinary use have been completed. Work on improvements in the construction of wood poles for overhead lines is now in hand. It is unfortunate that the preparation of experimental apparatus designed for the investigation of switching and arcing phenomena has been delayed by industrial troubles, but pressure-recording apparatus and a continuously operating high-speed camera with an aperture of *f*2·6 have been devised. The work on the relief of gaseous explosion pressures (in mining apparatus) through flanged joints has yielded some unexpected results, and the investigations are to be extended to cover other methods of pressure relief. The National Physical Laboratory has developed apparatus for measuring small losses by current leakage, and by its aid new results for mica have been obtained; certain preliminary work at low voltages has also been done on varnished cloths. Research on this subject has necessitated the development of a wattmeter for use at high voltages, and the Laboratory has obtained satisfactory results with this up to 10,000 volts. For the measurement of dielectric losses at high frequency, the Braun tube is being developed by Professor MacGregor-Morris with some success.

"THE DOCK AND HARBOUR AUTHORITIES' DIRECTORY, 1922."—This directory, giving a list of members of the dock and harbour authorities throughout the world and of their principal officials, is issued at 10*s.* 6*d.* net by The Yachtsman Publishing Company, Limited, 158, Strand, London, W.C.2. The ports, British and foreign, are dealt with in alphabetical order, and the information includes the name of the authority for each port, and the names of the chairman, commissioners or members of council and principal officers.

"DIRECTORY OF SHIPOWNERS, SHIPBUILDERS AND MARINE ENGINEERS, 1922."—This directory for the present year, the 20th year of publication, is compiled under the direction of the editor of *Shipbuilding and Shipping Record*, and is issued at the price of 20*s.* net, by the Directory Publishing Company, Limited, 33, Tothill-street, S.W.1. It gives a large amount of information on the leading steamship companies, shipbuilders, ship-repairers, and marine engineering works throughout the world. This information includes, in the shipping section, the names and addresses of the companies, of their principal officials, and the ships' names with passenger accommodation, speeds, tonnage, carrying capacity, whether oil-fuel burning, &c. In the shipbuilding section, the capacity of the shipyards and engine works are given, together with the dimensions of dry docks available for ship repairing. The book also contains a valuable reference directory of societies, institutions, trade and labour federations, consulting naval architects and marine engineers.

TURBINES, WITH MICHELL BEARINGS, OF THE T.-S.S. "GOUVERNEUR-GENERAL CHANZY."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

FIG. 2.

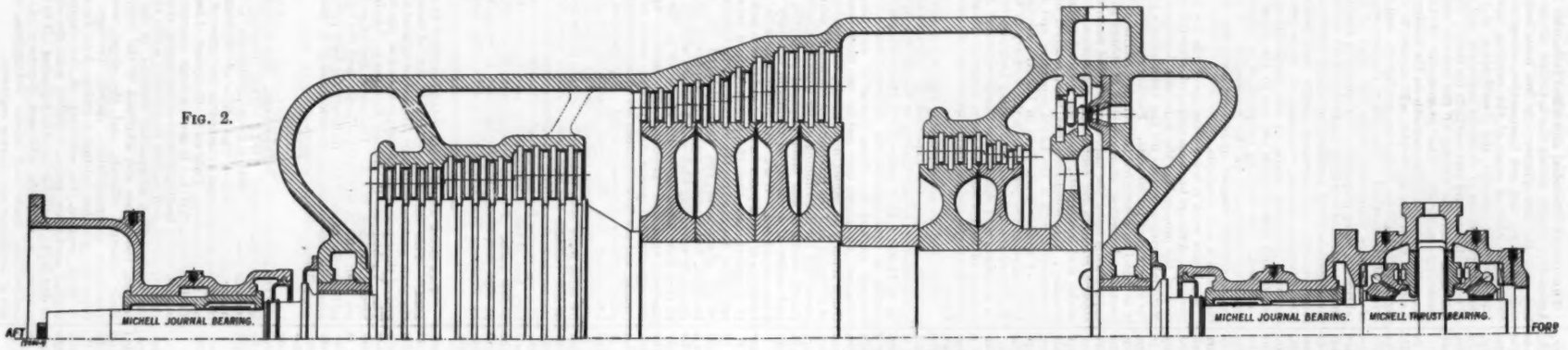
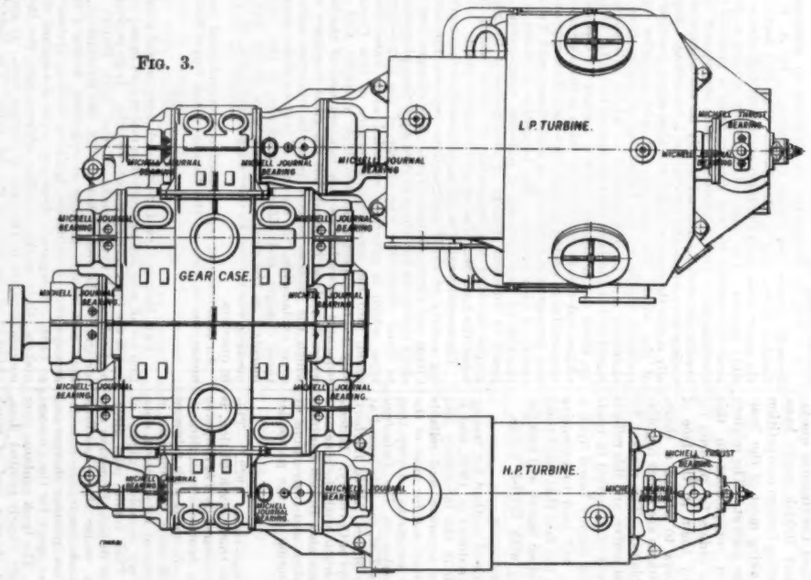


FIG. 3.



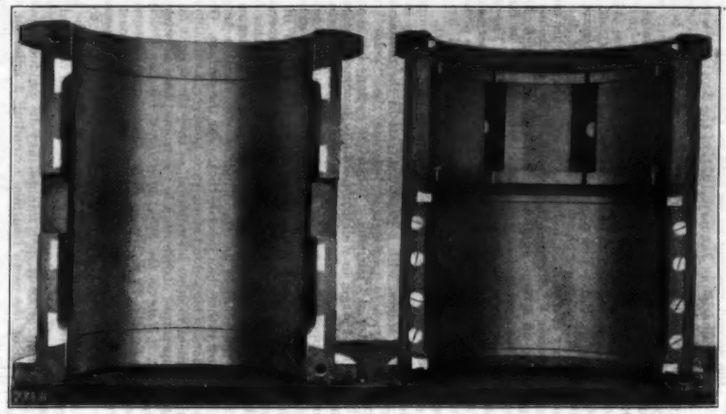


FIG. 4.

FIG. 5.

THE twin-screw steamship Gouverneur-General Chanzy, recently built by Messrs. Cammell Laird and Co., Limited, at Birkenhead, for Le Commission aux Transport Maritime et la Marine Marchands, for the mail, passenger and cargo service between Marseilles and Algiers, is notable for the fact that the whole of the main and thrust bearings of the propelling machinery have been constructed on the Michell principle. The boat measures 377·6 ft. in length by 53·1 ft. moulded breadth, whilst the moulded depth to the upper deck is 29·33 ft., and is designed to accommodate 162 first class, 84 second class and 56 third class passengers in addition to the officers and crew. The designed service speed is 19 knots. A general view of the ship is reproduced in Fig. 1, page 105. The propelling machinery is designed to drive the propellers at 140 r.p.m., through double-reduction gearing. The turbines are of the Parsons type. The high-pressure turbine, which is provided with a velocity-compounded stage at the stop-valve end, is designed to run at 3,500 r.p.m. The low-pressure ahead turbine is on the reaction principle throughout, and runs at 2,400 r.p.m. Astern turbines are incorporated in both the high-pressure and the low-pressure casings, and include a velocity-compounded wheel with two rows of moving blades in the high pressure case, and, as shown in Fig. 2, annexed, a similar wheel followed by a short reaction section in the L.P. casing.

A plan of the turbines and gear-case is represented in Fig. 3. The gearing was cut by the builders and is of the usual double helical type, the teeth being of $\frac{7}{8}$ in. nominal pitch, for the first reduction; and 1 in. nominal pitch for the second reduction wheels. The tooth form is of Messrs. Parsons' latest pattern. As already stated the whole of the bearings, which, including the thrust blocks, number 17 in all per set, are constructed on the Michell principle, this being the first marine installation to be completely fitted in this way. The construction of these bearings is shown in detail in Figs. 6 to 12, page 109. As will be seen in Figs. 6 and 10, each bearing consists of a housing containing six blocks or pads lined with white metal. These pads take the load on the shaft which they transmit to the housing through "line" contacts about which they are able to rock. Owing to the freedom thus afforded the blocks take up automatically such a position with respect to the revolving shaft that a wedge shaped film of oil forms between pad and shaft, thus ensuring lubrication under conditions which are almost ideal, both practically and theoretically. It has thus been possible to reduce the bearing area in some cases to about one-third of that usually provided. Since, however, the turbines and gear-case were originally designed for ordinary brasses, the Michell pads have had to be fitted to suit, and the housings are accordingly larger than necessary. The lubricating oil is supplied under pressure and is introduced between the pads, from which it escapes at the ends in the usual way. The photograph reproduced in Figs. 4 and 5 shows Fig. 4, the ordinary brass, and Fig. 5 the Michell "brass" which has replaced it.

The effect of the reduced friction with the Michell journal bearings was very noticeable during the steam test of the turbines and gearing in the engine shop. After shutting off steam the machinery continued to run under its own momentum for 13½ minutes, whilst

MICHELL BEARINGS OF TURBINES; T.-S.S. "GOUVERNEUR-GENERAL CHANZY."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

(*For Description, see opposite Page.*)

FIG. 6.

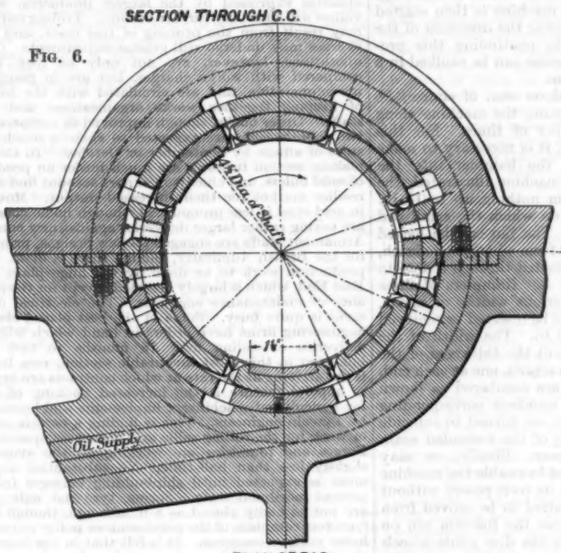
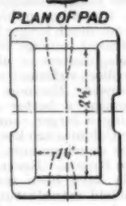


FIG. 8.



(7289.C.)

FIG. 7.

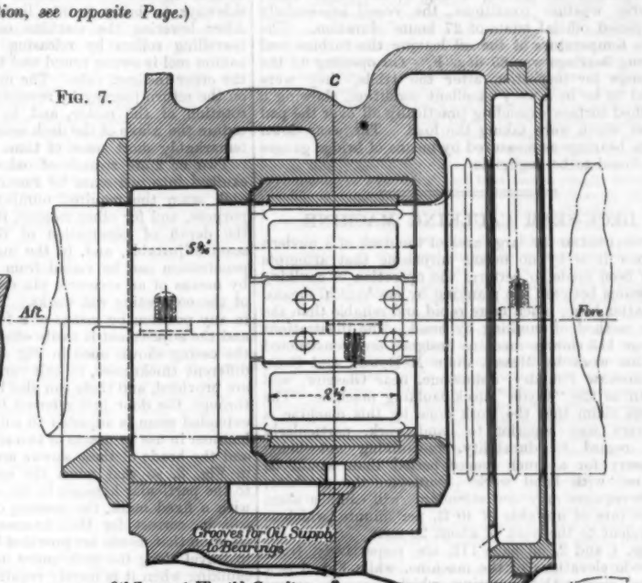
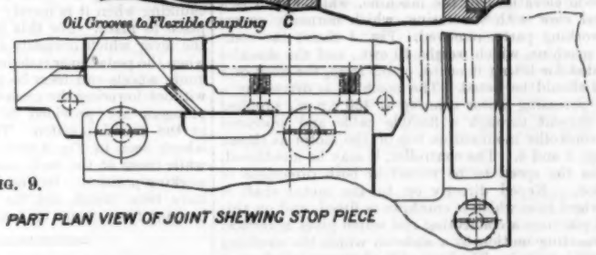


FIG. 9.



PART PLAN VIEW OF JOINT SHEWING STOP PIECE

FIG. 10.

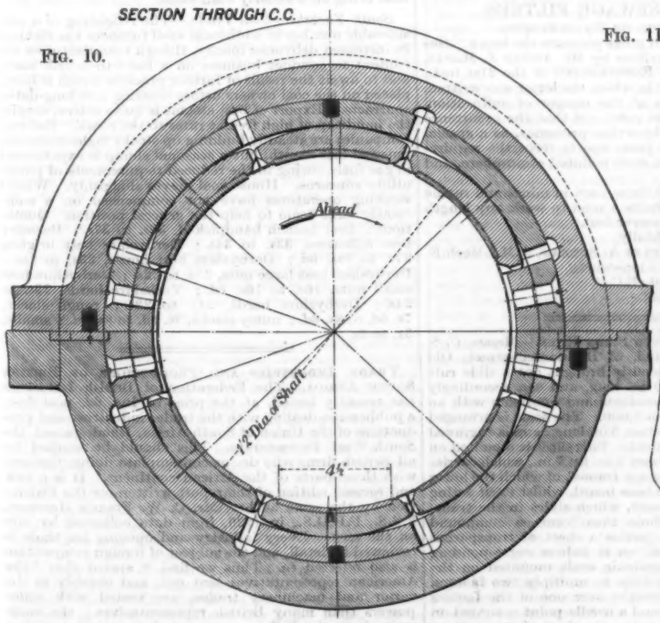
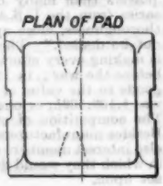
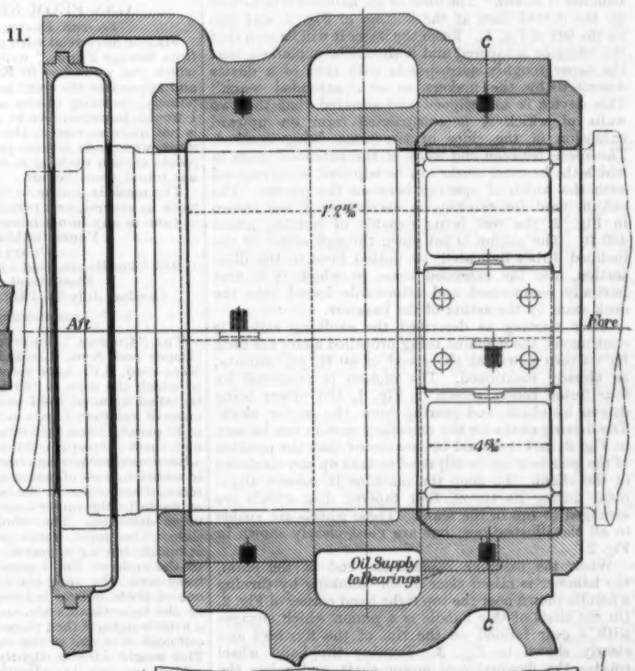


FIG. 12.



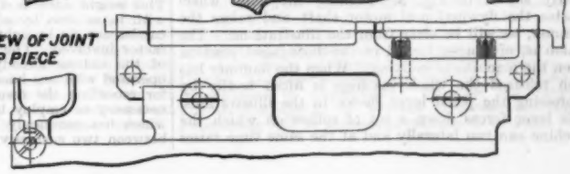
(7289.D.)

FIG. 11.



PART PLAN VIEW OF JOINT SHEWING STOP PIECE

FIG. 13.



a somewhat similar set of machinery with ordinary journal bearings under similar conditions ran for 9½ minutes. The bearings were designed for a maximum pressure of 550 lb. per square inch. of projected area and a maximum surface speed of 76·5 ft. per second. In addition to making a trip to the Clyde under adverse weather conditions, the vessel successfully completed official trials of 27 hours' duration. The mean temperature of the oil leaving the turbine and gearing bearings was 85 deg. F. On opening up the bearings for inspection after the trials, they were found to be in a very excellent condition, showing a polished surface extending practically all over the pad pieces which were taking the load. The wear down of the bearings as measured by means of bridge gauges was found to be negligible.

DECK-SEAM CAULKING MACHINE.

CONSIDERING the large area of the deck of a modern steamer it is by no means surprising that attempts have been made to perform the operation of caulking the seams between the planking by mechanical means, the latter being much more rapid and reliable than the older method of caulking by hand. The illustrations of page 112 show a machine designed and constructed for this work by Messrs. John McDowall and Sons, Walkinshaw Foundry, Johnstone, near Glasgow, and known as the "Clyde" deck-caulking machine. The makers claim that the work done by this machine is in every way superior to hand work, particularly with regard to durability, re-caulking not being necessary for a much longer period than would be required with hand work. Moreover, the machine, which requires only one attendant, will caulk a seam at the rate of upwards of 40 ft. per minute, which is equivalent to the work of about 20 men.

Figs. 1 and 2, on page 112, are, respectively, front and side elevations of the machine, while Fig. 3 is a general view with the casing, which normally covers the working parts, removed. Fig. 4 shows the complete machine, which weighs 10 cwt., and the shackles provided for lifting it on to, or off from, the deck of a vessel should be noted. The machine is driven by a 3-h.p. reversing motor running at 430 r.p.m., supplied with current through a flexible cable and operated by a controller mounted on top of the motor as shown in Figs. 3 and 4. The controller, it may be mentioned, enables the speed to be varied in both directions of rotation. Keyed directly on to the motor shaft is a flywheel into which a crankpin is fitted, and on this crank-pin runs a connecting rod which gives a vertical reciprocating motion to a slide on which the caulking hammer is bolted. The form of the hammer is indicated by the dotted lines at the bottom of Fig. 2, and also on the left of Fig. 1. From the latter it will be seen that the hammer is tapered and it should be explained, that the taper roughly corresponds with that of a device described by the makers as an "extended seam." This device is so designed and situated that the two walls of which it is constructed form an upward extension of the sides of the seam being caulked. The space between the walls of the extended seam in which the hammer works can be adjusted to correspond with the width of opening between the planks. The oakum used for caulking is carried on a reel shown in Fig. 2, the reel being capable of holding about 450 ft. The oakum is led down through either of the inclined tubes indicated by dotted lines in the illustration, into the extended seam in which it is first partially compressed and afterwards forced into the deck seam by the action of the hammer.

After starting as described the caulking action is continuous, the machine being propelled along the deck by its own power at the speed of 40 ft. per minute, as already mentioned. The motion is produced by four fluted rollers shown in Fig. 1, the rollers being driven by chain and gearing from the motor shaft. The driving chain for the travelling motion can be seen in Fig. 3, and it should be mentioned that the position of the gear-box can be adjusted to take up any slackness in the chain. To keep the machine in correct alignment during its travel, four tapered disc wheels are arranged to run in the seam. These wheels are visible in all the illustrations, but are most clearly shown in Fig. 2.

When the machine reaches the end of the seam, the hammer is raised clear of the planking by turning a handle shown near the top right-hand corner of Fig. 2. On the shaft of this handle is a pinion which engages with a gear formed on the rim of the flywheel and clearly shown in Fig. 3. Turning the hand wheel rotates the flywheel and motor shaft and raises the hammer, as will be clear from the illustrations. The pinion is, of course, locked in the disengaged position when the machine is caulking. When the hammer has been released the whole machine is lifted bodily by depressing the pedal lever shown in the illustrations. This lever forces down a set of rollers on which the machine can run laterally and at the same time raises the disc guide wheels out of the seam; an examination of Fig. 1 will enable the mechanism employed for this purpose to be followed. The rollers are operated through worm gearing and driving chains by a hand wheel situated at the back of the machine, near the deck level, and by this means the machine is moved sideways to bring it into line with the next seam. After lowering the machine on to the longitudinal travelling rollers by releasing the pedal lever, the oakum reel is swung round and the oakum fed through the other inclined tube. The machine is then started on the return journey by reversing the direction of the rotation of the motor, and by continuing this procedure the whole of the deck seams can be caulked in a remarkably short space of time.

Two or more strands of oakum can, of course, be caulked into one seam by running the machine along each seam the required number of times. For this purpose, and for other reasons, it is necessary to make the depth of penetration of the hammer into the seam adjustable, and, in the machine illustrated, the penetration can be varied from nothing up to 1¼ in. by means of an eccentric pin on which the small end of the connecting rod works. The pin can be locked in any position by means of a form of toothed clutch, and the adjustment is easily effected through a door in the casing shown open in Fig. 4. Hammers of three different thicknesses, to suit various widths of seams, are provided, and these can also be inserted or removed through the door just referred to. The width of the extended seam is adjusted to suit the thickness of the hammer in use by means of two screws, one at each end, and the heads of these screws are numbered as shown in Fig. 2, so that when the numbers corresponding to the particular hammer in use are turned to coincide with a fixed mark, the opening of the extended seam will be correct for that hammer. Finally, we may mention that means are provided to enable the machine to travel along the deck under its own power without caulking when it is merely required to be moved from place to place. For this purpose the fulcrum pin on the lever which normally raises the disc guide wheels when the pedal lever is depressed, is withdrawn, and the guide wheels can then be pulled up clear of the deck without lowering the cross-travel rollers; small spring plungers are provided to retain the guide wheels in the raised position. The foremost pair of guide wheels seen in Fig. 3 have been raised in this manner, while those at the back have been left in their normal working position. In Fig. 4 both pairs of guide wheels have been raised, and the fulcrum pins can be seen hanging from chains on both sides of the machine.

GAS FROM SEWAGE FILTERS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great pleasure the letter "Gas from Sewage Filters," written by Mr. Arthur J. Martin, which you published in ENGINEERING of the 21st inst., and appreciate the spirit in which the letter was written, namely, warning others of the danger of suffocation. I would, however, like to point out that the occurrence is not quite so rare as the writer presumes, as a special mask was made several years ago to meet the requirements of men working in such polluted atmosphere, and has found great favour.

The mask is similar to those used in mines and rescue work in general, and permits a man to work any length of time in any fumes however bad.

Yours faithfully,

CHARLES A. SUCKAN, A.M.I.Mech.E.

Red Lion House, Red Lion-court,
Fleet-street, E.C. 4.
London, July 24, 1922.

THE "COOPER" 100-INCH SLIDE RULE.—Messrs. C. S. Cooper and Sons, Limited, of Haddonhall-street, Old Kent-road, S.E., have recently brought out a slide rule in which the scale is 100 in. long, and can accordingly be relied upon to yield products and quotients with an error of less than 1 part in 1,000. The scale is arranged in 20 parallel lines, each about 5 in. long., and is engraved on a sheet of opaque celluloid. This sheet is mounted on a baseboard measuring about 8 in. by 7 in., which carries in addition, a set of mahogany frames, of which the lower rests on and slides on the base board, whilst itself acting as guide to the upper frame, which slides in the transverse direction. The whole thus forms a compound slide. The upper frame carries a sheet of transparent celluloid, having engraved on it indices corresponding to the ends of the logarithmic scale mounted on the baseboard. In using the slide to multiply two factors, one of these indices is brought over one of the factors on the logarithmic scale, and a needle point mounted on a little weight, is then placed on the sheet of transparent celluloid over one of the ends of the logarithmic scale. This weight adheres slightly to the celluloid and moves with it, so that by adjusting the frames the needle it carries can be brought into coincidence with the other factor involved. The product is then read under one of the indices already mentioned. The rule can be operated with one hand, whilst the other holds the pen for recording the results. In general, it is of course necessary to employ both hands in using a slide rule, which has commonly to be picked up and laid down between two successive operations.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Though prices are favourable, and there is a marked diminution in the former volume of German and Belgian competition, new business is not coming to hand with quite the readiness that was expected by the more optimistic engineering masters. Buyers still show exceptional caution in placing orders for delivery over more than three months. At the same time it is extremely doubtful, according to the opinions expressed by the largest producers, whether values will show any further decline. Trifling reductions may result from the pruning of fuel costs, and labour charges may undergo still greater adjustments. Current quotations, however, are not only at rock bottom compared with works charges, but are in many cases unremunerative, and are circulated with the sole idea of keeping together works organisations and expert staffs. Order books, though improved as compared with two months ago, are expected to show a much better state of affairs by September or October. In the steel-making section furnaces are much busier on production of mild billets, and chiefly on export account find a much readier market for their increased output. Movement in acid steel is less pronounced, though home consumers are taking rather larger deliveries against new contracts. Armament staffs are engaged on new designs, principally for the British Admiralty, though there is little, if any, production work to be done by the huge plant in the East End, which is largely deserted except for the attendance of maintenance engineers. The electrical department is quite busy. Some of the best-placed electrical engineering firms have orders in hand which will cover deliveries extending over 18 months to two years, but even in this most favourable section, new business is not arriving at the rate at which contracts are expiring. A hopeful feature is the increased booking of orders for agricultural machinery, implements and locomotives by Lincoln engineers. This is finding a certain amount of work for the rolling mills and makers of special steel. Forges and foundries are working on the average at slightly less than half-time. No substantial improvement is expected until shipbuilding emerges from its present moribund state. Spring, tyre and axle plants are not so badly placed as a month ago, though manufacturers complain of the parsimonious policy pursued by home railway concerns. It is felt that in the interest of the travelling public, substantial orders for renewals cannot much longer be withheld. Sheffield is sending an increased tonnage of tool steel to America, but, on the whole, makers of alloy materials have a difficult task to collect sufficient ready money to meet their overhead expenses. Business in the lighter sections is gradually assuming a better appearance. British engineers are taking a larger tonnage of files and other hand tools. The Colonies are keeping closely in touch with the latest price developments, and more business is in prospect from Russia. Recent deliveries of saws, augers and edge tools have been made to the mutual satisfaction of Sheffield manufacturers and of Russian importers, business being on a strictly cash basis.

South Yorkshire Coal Trade.—The relighting of a considerable number of additional steel furnaces has resulted in increased deliveries locally, though manufacturers are content to conduct business on a hand-to-mouth basis, and to await the result of further pressure which is being placed on the coal owners before entering into long-dated contracts. Export of best steams is quite active, despite the handicap of high freight rates to the coast. Railway companies are steadily building up stocks under contracts renewed last month, but a seasonal slump is experienced in gas fuels, owing to the reduced requirements of public utility concerns. House coal moves sluggishly. Winter stocking operations have not commenced on a sufficiently large scale to help the general position. Quotations: Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire best small nuts, 16*s.* to 16*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

TRADE, INDUSTRIES AND PRODUCTIONS OF BRITISH SOUTH AFRICA.—The Federation of British Industries has recently issued, at the price of 10*s.* 6*d.* post free, a publication dealing with the trade, industries and productions of the Union of South Africa, Rhodesia and the South-West Protectorate. This should be studied by all British firms who do, or contemplate doing, business with those parts of the African continent. It is a new and revised edition of the report written for the Federation by the same author, Mr. C. W. Francis Harrison, F.S.S., F.R.G.S., in 1920, from data collected by him on the spot. Every industry and opening for trade is reviewed in detail, and the subject of foreign competition is also referred to. Thus we find it stated that "the American representatives sent out, and notably in the motor and machinery trades, are vested with wider powers than many British representatives; the emissaries from the U.S.A. carry out their missions with a thoroughness, close application and keenness that cannot be denied." The author notes also that Germany is making every effort to recapture the business she had before the war; in 1919, she exported to South Africa goods to the value of 29,896*l.*, whilst in 1921 the figure was 1,132,582*l.*, or one-third of her trade before the war. The competition of other countries is also referred to. Besides manufacturers and merchants, the report would also interest members of trade unions, several paragraphs in which they would do well to meditate seriously and to act upon.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues quiet. Home demand is only very moderate, and for the time being sales to the Continent are almost nil. American inquiries are still circulating, but they are the naval negotiations for ferro-manganese, and other special irons. It is disquieting to learn of a little Midland pig-iron coming to this district, and another unsatisfactory feature is the report of more sales of foreign iron to Scotland through merchants here. No. 1 Cleveland and silicious iron are as scarce as ever, and are firm at 95*s.*, but other qualities are in ample supply and are easy at No. 3 G.M.B., 88*s.*; No. 4 foundry, 87*s.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.*; all f.o.t. makers' works or f.o.b. Tees.

Hematite.—East Coast hematite is plentiful, and values tend easier. Producers no longer adhere to 94*s.* as the home price of Nos. 1, 2 and 3. They are now sellers at 93*s.*, which, however, is still more than customers will pay. No difficulty is experienced in placing orders for mixed numbers for abroad at 91*s.* No. 1 hematite is put at a shilling above mixed numbers.

Foreign Ore.—There is next to nothing doing in foreign ore. The price of best rubio is given at 25*s.* c.i.f. Tees, but doubtless orders would be accepted at less.

Blast-furnace Coke.—Durham blast-furnace coke is certainly a little stronger, but it has hardly moved up. Some sellers now ask 27*s.* for medium sorts delivered, but that is a higher figure than local consumers are prepared to pay, and it is understood that business can still be put through at 26*s.* 9*d.*

Manufactured Iron and Steel.—Just a little more appears to be passing in one or two branches of the finished iron and steel industries, but generally the situation continues most unsatisfactory, a great deal of machinery being still inactive. The following rates are still named for home trade, but export contracts can be arranged on substantially lower terms: Common iron bars, 12*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; steel billets (soft), 7*l.* 15*s.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel ship, bridge, and tank plates, 10*l.*; steel boiler plates, 13*l.* 10*s.*; steel angles, 9*l.* 10*s.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 16*l.*

LIGHT DUES.—The Board of Trade have considered the possibility of reducing the light dues, and have arrived at the conclusion that the position of the General Lighthouse Fund will permit of a reduction in the dues by 15 per cent. on present charges, which are now 100 per cent. above the statutory scale. Drafts of the Order in Council necessary to give effect to the reduction have been laid before both Houses of Parliament, and as such drafts must lie before both Houses for thirty sitting days, in accordance with statute, it will not be possible to bring the reduction into force before October next.

THE PROGRESS OF CIVIL AVIATION.—The half-yearly report, dealing with the progress of civil aviation, just issued by the Air Ministry, is the sixth of the series and covers the winter period from October, 1921, to March, 1922. The statistical tables included in the report indicate that, in general, a steady rate of increase has been maintained, and that the efficiency of the British Continental services has improved. The total number of passengers arriving and departing on British machines during the period was 1,686, as compared with 1,418 during the corresponding period in 1920–21, and 796 in in 1919–20. That the British companies have carried the greater part of the total traffic will also be evident from the fact that the arrivals and departures on machines of all nationalities, flying on all cross-Channel routes, during the three half-yearly periods above referred to were 2,511, 2,023 and 887, respectively. A very considerable increase in the traffic is necessary, however, if the aerial transport firms are to be successful on an ordinary commercial basis.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—The British Engineering Standards Association held its Fourth Annual General Meeting on Thursday, the 13th inst., at the Institution of Civil Engineers, when the chairman, Sir Archibald Denny, Bart., presented his annual report and made a review of the position. The report stated that there are now nearly 2,000 engineers who give their time and experience to this national institution. Last year just under 17,000*l.* were expended, towards which industry, in spite of the depression in trade, contributed 9,300*l.*, the remainder coming from the Government, the India Office and the Governments of the Dominions overseas. The chairman thanked all those firms who had so liberally supported the Association; at the same time he felt that the latter should not have to live quite so much from hand to mouth, and should be able to build up a small reserve. This could be accomplished without difficulty if industry would still further increase its subscriptions and the many firms, who so far, did not financially assist would agree to become annual subscribers. The report reviewed the progress of the work in the various sections, and referred to the work of the Aircraft Section, which should play an important part in the reconstruction of that branch of industry so much before the public at the present time. Other sections were also dealt with. The Association issued 72 new and revised specifications during the year, and the sales of the publications had reached 39,000, in addition to a very large number of aircraft specifications distributed on behalf of the Air Ministry.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Repairs, &c., are the order of the day this week at most of the Scottish steel works, and very little plant has been put into operation yet. Trade is very sluggish, and since the stoppage, the tonnage booked is of very small dimensions. Perhaps when the holiday spirit passes off, buyers may be more inclined to enter the market, but at the present moment there seems to be little inclination to do much, if any, dealing, with the result that the various works will "go easy" when operations are resumed. A general start will be made next week, but, of course, except in one or two cases, there is little to commence with. There are a number of inquiries going around at present, both on home and foreign account, and producers are quite hopeful of fixing up some of these. The main trouble to be faced, however, is that buyers want much lower rates than now exist, and unless these can be secured, only their most immediate necessities will be contracted for. The feeling that we are on the eve of better times is daily gaining more ground. No change has been made in quotations which are as follows:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, 11*l.* 5*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable iron trade, the prevailing conditions are not very encouraging, and where a re-start has been made this week, it has not been satisfactory because of the poor state of order books. The majority of the works will get under weigh in another week or so, but the outlook is, meantime, not very bright. Although there are few orders being placed, there are a fair number of inquiries. The price of "crown" bars is steady at 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—Quite a good tone is prevalent in the pig-iron trade of Scotland, and there are signs of an opening out of business in the near future. For foundry iron there has been a fair demand lately, and some works have a moderately good amount booked, while the order books of some of the others are rather bare. Hematite is in poor demand, although there are prospects of more doing before long. The export outlook is again better, and a number of inquiries are in the market on behalf of American consumers, but the prices on offer are not likely to lead to much business being fixed up. Quotations, as a matter of fact, have a firmer tendency, and although hematite is still called 5*l.* 8*s.* 9*d* per ton delivered at the steel works, foundry iron is the turn dearer at 5*l.* per ton for No. 1, and 4*l.* 15*s.* per ton for No. 3 quality loaded into trucks at makers' works.

River Clyde Ferries.—The Statute Labour Committee of Glasgow Corporation has approved of the proposal of the Clyde Trustees to build two new ferry boats, and acceptance of the offer of Messrs. Harland and Wolff (Limited), to construct the hulls of the vessels for the sum of 1,590*l.* each; while the two engines which are to cost 1,130*l.*, are to be made at the Clyde Trust workshops. The Clyde Trustees also agreed that Merryweather fire engines, costing 845*l.* each, should be put in the boats, but the Statute Labour Committee recommended the Corporation not to agree to their installation.

AIRCRAFT IN NAVAL WARFARE.—Owing to the fact that somewhat exaggerated accounts of the effects of the attack on the Atlantic Fleet by torpedo-carrying aeroplanes, recently carried out in the presence of His Majesty the King, have been circulated, the Admiralty has issued a statement explaining that the attack was arranged more with regard to spectacular effect than as a critical experiment in methods of naval warfare. The element of surprise was entirely lacking, and the attack was quite undisturbed by any counter-offensive action on the part of the naval vessels. The conditions were thus entirely favourable to the aircraft, but in spite of this fact, the number of hits obtained on the battle line was small, and of minor tactical importance. It should thus be apparent that since the conditions of the attack bore so little resemblance to those existing in actual warfare, no useful conclusions as to the effect of this class of aircraft on the security of the Fleet can be drawn from these exercises.

STANDARD PIPE FITTINGS.—The British Engineering Standards Association has issued two Reports, Nos. 143 and 154, dealing with malleable and soft cast-iron pipe fittings of nominal sizes from ⅛ in. to 4 in. Both the reports contain, among others, clauses relating to special sizes of reducing fittings, screw threads and the method of specifying outlets. These are followed by tables of dimensions of British Standard Equal and British Standard Reducing Fittings, and the reports conclude with type deawings of the fittings, together with a diagram indicating the method of setting out the curves of the reducing fittings. The reports also give special tables by means of which the "centre to face" dimensions for reducing fittings can readily be ascertained, a most useful feature both for the manufacturer and the installation engineer. The Report, No. 143, "British Standard Dimensions for Long Sweep Type Malleable Iron Pipe Fittings for Steam, Water and Gas," is limited to fittings designed for use where the maximum "delivery head" is needed and where the question of frictional resistance is important. The fittings dealt with are bends, elbows, tees and crosses. The Report, No. 154, "British Standard Dimensions for Malleable and Soft Cast-Iron Pipe Fittings for Steam, Water and Gas," includes all fittings in use, such as sockets, caps, elbows, hexagon nipples, return bends, tees and crosses.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The demand which set in for Welsh coal on American account has broadened during the past week, and it is believed that orders for at least 500,000 tons have already been placed for shipment over this and next month. As the business has been placed through various merchants, it is practically impossible to calculate with any degree of accuracy the extent of the inquiry. That it is of a substantial nature will be gathered from the fact that already 50 vessels, to carry 300,000 tons, have been chartered, while it is known that a number of steamers have been fixed, particulars of which have not transpired. In addition, the United States Shipping Board have allocated American tonnage to merchants to ship bought coals on an f.o.b. basis. On the coal market the price of best Admiralty large has jumped from 24*s.* 6*d.* to 30*s.*; Monmouthshires from 24*s.* to 27*s.* 6*d.*; and best steam smalls from 18*s.* to 21*s.* Other grades, too, have been indirectly affected by the American demand for No. 2 Rhondda large, which a week ago was obtainable round 21*s.*, now commands 25*s.*, and throughs 21*s.*, against 19*s.* Already operations at the local docks show more activity. At Cardiff, for instance, 35,000 tons of coal were loaded on Monday, which is the largest single day's shipment since the war. The pressure for supplies from America has also brought other buyers into the market, and it is expected that work at the collieries will be more regular during the next month than has been the case for some time past. Prior to the American demand, a number of pits were closed while the majority were working short time, because of the lack of trade. Some thousands of wagons, too, were held up at the docks under load. All this is now changed, for at the docks the coal tippers and trimmers are making a rapid clearance of the accumulated stocks and the railway companies are rushing empties back to the collieries. A week ago tips were lying idle, but to-day shippers experience difficulty in securing loading berths. On the freight market business also has been active, and rates have considerably increased. Tonnage was first of all chartered for the United States at 7*s.* 6*d.* free delivery, which was subsequently increased to 8*s.*, 8*s.* 6*d.*, 9*s.*, 10*s.* 6*d.*, 11*s.*, 12*s.* 6*d.*, and to-day 13*s.* was secured with shipowners holding for 15*s.* Other sections are also firmer, and 12*s.* 3*d.* has been done for Genoa, compared with 11*s.* a week ago.

Iron and Steel.—Exports of iron and steel goods in the past week amounted to 16,811 tons, which was double the quantity shipped in the previous week. Of the total 7,759 tons were tinplates, compared with 5,076 tons, 4,201 tons galvanised sheets against 70 tons, 2,844 tons iron and steel against 655 tons, and 2,007 tons black-plates against 1,765 tons.

FLUORSPAR INVESTIGATIONS.—R. B. Ladoo, mineral technologist, of the United States Bureau of Mines, recently spent a month in the southern Illinois and Western Kentucky fluorspar field in order to complete the investigation of the fluorspar industry. The outstanding feature with regard to fluorspar is that our known reserves are very low, and unless new deposits are found it will be very scarce and expensive within a few years. The development of possible substitutes is being considered. The object of the recent investigation is the eventual preparation of a bulletin on all phases of the fluorspar situation.

THE ELECTRIC VEHICLE COMMITTEE OF GREAT BRITAIN.—At the meeting of the Electric Vehicle Committee of Great Britain, held at the Institution of Electrical Engineers on the 13th inst., Mr. J. A. Priestley, Cleansing Superintendent of the Sheffield Corporation, was elected Chairman of the Committee, and Mr. W. H. L. Watson, of Electricars, Limited, and Mr. W. Worby Beaumont, were elected Vice-Chairmen. Mr. F. E. Hoadley was re-elected Hon. Secretary, and Mr. J. Christie, Hon. Treasurer. A cordial vote of thanks was passed to Mr. F. Ayton, the retiring Chairman, for his long services on behalf of the Committee.

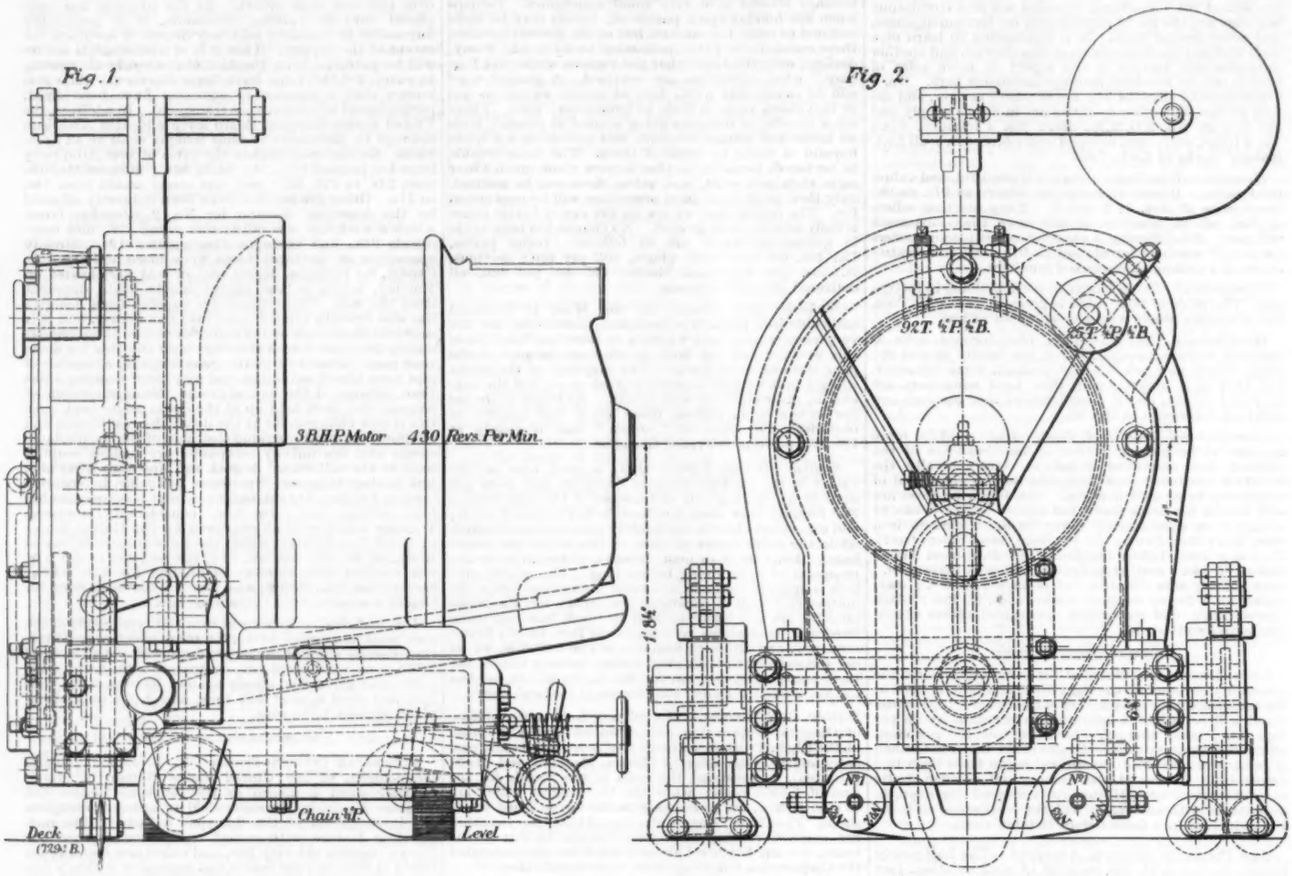
BRICKS FROM DOLOMITE.—At the ceramic experiment station, Columbus, Ohio, the United States Bureau of Mines, has made standard-sized bricks from calcined dolomite and from raw dolomite using 10 per cent. of the flux Fe_2O_3, Al_2O_3, SiO_2. Calcined dolomite was found undesirable for making into bricks as the mud slaked so rapidly, and, on account of enormous shrinkage during drying and burning, all samples cracked badly. Raw dolomite, together with 10 per cent. flux, gave excellent promise. The bricks so burned to 1,450 deg. C. were sound, of high density and had not shown signs of slaking when subjected to the boiling test.

DEEPENING THE SOUND PAST COPENHAGEN.—The question of deepening the Drogden, the channel on the Danish side through the Sound, has often been proposed during the last 20 years or more, but the scheme has had opponents who hitherto have managed to impede its realisation. The Government, however, are now prepared to further the scheme, and the new channel will, in the first instance, have a depth of 24 ft. and a breadth at bottom of 250 metres. It has not been possible to calculate the exact cost; before this can be done some additional borings are necessary. No doubt, an improved channel will be of considerable importance to Copenhagen. Whether the proposed depth will suffice, or whether a subsequent further deepening will be necessary, remains to be seen.

THE "CLYDE" DECK SEAM CAULKING MACHINE.

CONSTRUCTED BY MESSRS. JOHN McDOWALL AND SONS, ENGINEERS, JOHNSTONE.

(*For Description, see Page* 110.)



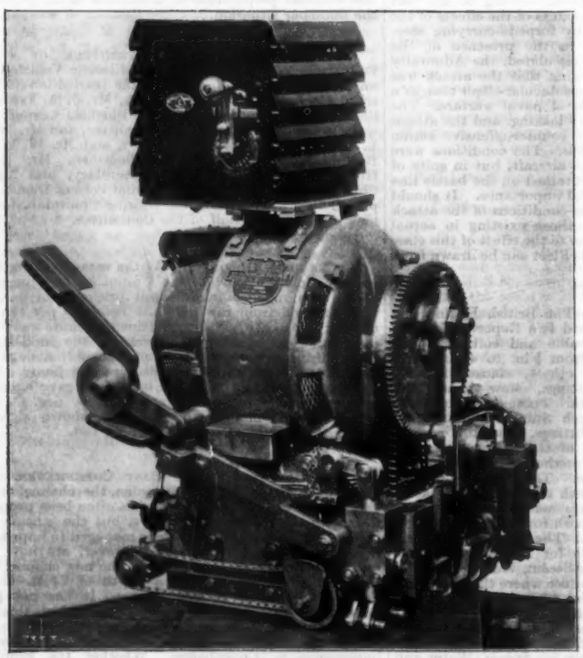


FIG. 3.

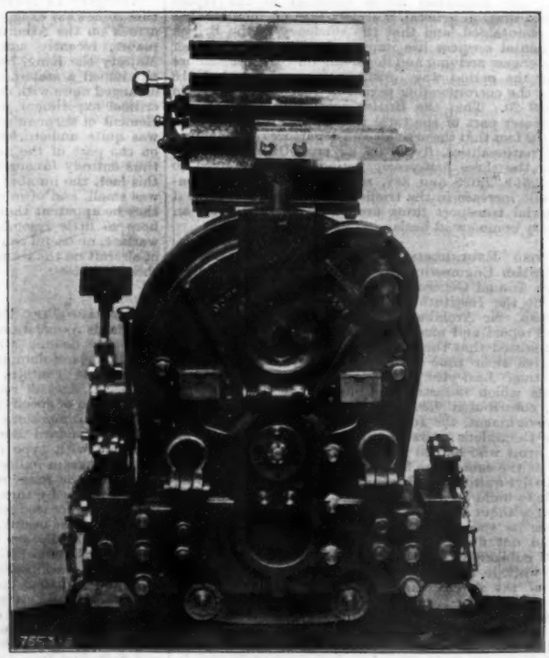


FIG 4.

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ENGINEERING.

FRIDAY, JULY 28, 1922.

THE NEW RULES OF LLOYDS' REGISTER.

THE intimation just issued by the Secretary of Lloyds' Register that the Committee of our premier Classification Society has adopted new rules for the construction of steel vessels, serves as a reminder that the present depression in shipbuilding will not last for ever, and that the keen and far-seeing shipowners and shipbuilders, who are members of the Committee, are making preparations for the time when normal business will be resumed. The last thorough revision of the Rules of Lloyds' Register was made in 1909, prior to which time the basis of scantlings had remained practically unaltered since the early days of iron vessels, despite the many changes in structure and type that had taken place in the intervening years. The revision of 1909 was a great stride forward, and the work now issued may be said to complete the transformation then made, and to bring the Rules thoroughly into line with modern practice and to embody the most up-to-date ideas in shipbuilding. Lloyd's Register is, of course, in a specially fortunate position, not only in the possession of a qualified technical staff, but also in the world-wide extent of its operations, which, by the co-operation of the branch Committees in different countries, enables a considerable volume of constructive criticism to be brought to bear from different standpoints on new proposals.

One of the most important points in which the new Rules differ from their predecessors is to be found in the fact that, for the first time in its history, Lloyds' Register has recognised the principle that, within limits, scantlings should be based on draught, and this feature is one which will appeal to both owners and builders. The problem of adjusting scantlings to draught is by no means as simple as it would appear at first sight, and various methods have been adopted by Classification Societies to overcome the difficulties of the question. One form which the correction has taken has been the modification of the scantling numerals by coefficients based on the ratio of draught to depth while in another case the scantlings are obtained by means of a series of formulæ, which probably give satisfactory results, but are complicated by a series of irritating corrections.

Lloyds' Register have sought a solution by providing sets of Tables for two classes of vessels, the full scantling type and the complete superstructure type, the former of which is entitled to the maximum geometrical draft permitted by the dimensions, while in the latter, the draft corresponds to that of the present-day shelter-deck vessel. For vessels having drafts intermediate between those of the two types, the scantlings are to be obtained by proportional interpolation. This method of relating scantlings to draft has much to recommend it, providing, as it does, a sufficiently close degree of approximation with simplicity of application, the only calculations necessary being the determination of the drafts of the two standard types.

The system of numerals which is characteristic of Lloyds' Register, has been retained, but several modifications in the methods of computing these numerals have been introduced. As will be remembered, prior to 1909, the scantlings of the frames were regulated by a numeral formed by the addition of the half-breadth, depth and half-girth, the latter dimension being dropped in 1909, since which time the frame number has been the sum of the breadth and depth. The considerations which led to this reform in 1909 have now been carried further, and in future the size of the frame and the frame spacing will depend only on the depth of the vessel (associated as at present with the unsupported span of the frame), an arrangement which appears to be quite reasonable since there is no apparent relationship between the breadth of the vessel and the scantlings of the side framing. In keeping with the general tendency in shipbuilding, the standard frame spacing provided in the Rules has been increased, and the fitting of side stringers is not now required.

In view of the transverse numeral no longer being employed, the numeral by which the scantlings of all the longitudinal members, except the topsides of the vessel are governed, is formed of the product of the length and depth, the present longitudinal numeral being retained for the topsides.

A very marked improvement has been effected in the Tables giving the scantlings for the topsides. Hitherto Lloyds' Rules have been somewhat indefinite regarding the permissible breadths of hatchway and other openings in the decks and the practice of requiring a second or third steel deck to be fitted at arbitrary points in the Table resulted in abrupt discontinuities in the standard of strength. In the revised Rules it is provided that where the breadth of the deck openings differs from that stipulated, the thickness of the deck plating is to be increased or reduced, subject to the provision of a minimum thickness. Columns are given showing the thickness required for weather deck plating according to the number of steel decks fitted, and a further column gives the increase in thickness required in proportion to the length of the vessel covered by superstructures, while similar provisions are made for the scantlings of long bridges.

As will be remembered, the Bulkhead Committee in their report issued in 1915, included Tables giving suggested bulkhead scantlings which were subjected to some criticism on the ground that they were greater than necessary. This question has again been under consideration internationally, and the modified scantlings, which show some reductions from the previous requirements, particularly as regards the brackets at the ends of the stiffeners, have been included in the Rules.

In addition to the alterations to the principal scantlings, advantage has been taken of this opportunity to formulate rules for a number of details, particulars of which had not been previously published. Oil-fuel bunkers are dealt with at some length, and owners are rightly encouraged to provide means, by fitting relief valves or otherwise, of preventing an undue pressure coming on the tank, as there is no doubt that the practice of carrying the overflow pipes to the weather deck results in stresses prejudicial to the structure.

The popular arrangement of bulb angle floors

in double bottoms is provided for, while as a matter of detail, the method of obtaining the scantlings of masts in steamers has been simplified. Regarding the scantlings broadly, it may be said that in general there is a reduction in the thickness of the shell plating accompanied by an increase in the thickness of the deck plating, the combination resulting in a structure in which the necessary standard of strength is maintained with a saving in the weight of material employed. The amount of this saving varies, of course, with the size and type of ship, but may be taken as approximately 3 per cent. in vessels of average dimensions. The Rules for the construction of oil vessels, first published in 1909, and representing the practice at that time, have become practically obsolete through disuse on account of the rapid growth in popularity of the longitudinal system for vessels of that type, and have now been withdrawn, the issue of new Rules for oil vessels, presumably based on the longitudinal system, being at present under consideration.

Without doubt, it may be said that the Rules just issued mark a very considerable advance in shipbuilding practice, and reflect great credit on the Technical Committee and the staff of Lloyds' Register, while the indebtedness of the world's shipping interests to Lloyds' Register is again emphasised by this work, which is one more addition to the labours of a century of disinterested public service.

THE UNITED STATES POWER COMMISSION.

IN view of the establishment in this country of the Electricity Commission, and of the talk, following upon the final report of the Water Power Resources Committee, of a national commission to regulate and co-ordinate the use of our water-power resources it is of some interest to examine in this connection the situation in the United States. In 1920 approval was given at Washington to the Federal Water Power Act, which provided for the appointment of a Federal Power Commission. There is no reason to doubt that the Commissioners subsequently appointed are anything but very good commissioners, or that the Act so far as it goes is anything but a very good Act, but from the first annual report recently received we gather that there is missing an almost vital link in the chain of organisation required to put the theory behind the Act into practice.

The Act is intended to co-ordinate the uses made of water resources, paying due regard to the requirements of navigation, irrigation and other possible uses of the water—in fact, to ensure that the power schemes adopted shall be all-round the best possible in the light of present knowledge, and that they shall be consistent with the use of necessary water in other and perhaps even preferable ways. It is, for instance, intended that, if water is required to maintain commerce by navigation, present or prospective, or to irrigate valuable lands capable of healthy and sound development, it shall not be possible for a power project to spoil a scheme promising larger benefit to the country as a whole. The Commissioners therefore have to consider the entire matter from the broadest possible point of view, and not merely from that of producing the maximum amount of power from the water supplies of the country. In order to ensure this broader view care has been taken in the appointment of the commissioners to avoid technical specialists, though technical advice is, of course, available to them. The commissioners are three in number. They are the Secretary of War, who acts as chairman, the Secretary of the Interior, and the Secretary of Agriculture.

The only staff which this Commission is empowered to employ direct is a secretary; beyond the capacity of this official the whole of the necessary work has to be performed by means of borrowed services, assignments of *personnel* from the departments of War, Interior and Agriculture being sanctioned for the purpose. We see that on it being decided what *personnel* was required for the new organisation action "was promptly taken by the respective secretaries" to lend to themselves as the Commission such staff as they could furnish. But here they were faced with one or two difficulties. As secretaries of departments they no doubt required all their staff for their own work, but to give the Commission a start they were evidently prepared to make some sacrifices.

So the Secretary for War found a few officials and subordinates, and the Secretary of the Interior decided to spare an official and a few details, and the Secretary of Agriculture also contributed some, and the three secretaries as commissioners formed all these into a staff for duty with the Power Commission, and then proceeded as commissioners to sympathise with themselves as secretaries on the reduction of their departmental *personnel*. It is fairly evident that the three commissioners, both as such and as secretaries of departments, are of the opinion that the Commission's work and that of their departments is being hampered for lack of adequate staff. It has been possible in the way we have related to get together a certain number, but even to do this it has been necessary in some cases first to transfer an official from some entirely distinct department such as Finance, to one of the three from which the Commission is permitted to borrow staff. And even so the range of requirements of the Commission is not met. A part of the duties falling to it under the Act is concerned with valuation, but we observe that "no work of this character has been done by the three departments, and they have no *personnel* with the necessary training or experience"—so the secretaries cannot provide the Commission with suitable men, with the result that this part of the work is left undone.

Clearly, then, it would seem that though the idea of the Act and of the Commission is admirable, the manner in which it works out leaves much to be desired. We are not in close enough touch with domestic politics in the United States to know what the exact idea behind this special staff-on-loan scheme is. If it had been introduced here we would have concluded that it arose from the common view that Government employees are as a rule not overworked, and that the time was not appropriate for new appointments to already swollen staffs, The tendency in all countries since the war has been generally to multiply offices, and it may be that some effort to stem this tide has had for its result this hampering of what otherwise would appear to promise to be a most valuable part of the Administration of the United States.

The Commission sets out eight complaints in its first annual report any one of which is serious enough to hinder its work. Owing to insufficiency of staff, it cannot keep pace with its work as applications are reported on by the field staffs of the departments. The field staffs are in turn insufficient to deal with the work assigned to them. The necessary comprehensive investigations are impossible. It is impossible to enforce the safeguards which it was intended should accompany the issue of licences. It is impossible to undertake valuations, neither is it possible to apportion costs between the several departments correctly. Instead of substituting one administration for three, it has for all practical purposes resulted in the establishment of a fourth; while, as the greater part of the work is being done by the departments, the Commission cannot organise effectively for economical working. The commissioners therefore appeal for the immediate amendment of the Act in order that it may at least have staff of its own.

All conditions have combined of late years to give an extraordinary impetus to hydro-electric developments in the United States, but under previous Acts security of tenure was so small that practically nothing was actually accomplished. The new Act, with its permits and licences extending to fifty years, has naturally resulted in all the schemes which have hitherto been waiting a favourable turn of legislature, being suddenly brought to the Commission, with many others which have resulted from the consequent interest aroused by movements of this kind. It is therefore not surprising in so large a country as the United States that a large number of schemes should require investigation and that the Commission should find itself practically "snowed under." Of course, when the major investigations are complete, and when the information is all properly filed, and the country mapped out and the resources of each watershed properly allocated between navigation, irrigation, power, municipal supply and all the other serviceable purposes to which it can be put, it will be possible perhaps for the commissioners, their secretary, and a borrowed clerk or two to do all that will fall to their share. But in the early days when every scheme has to be considered in relation to unknowns, unless the task is going to be performed badly, and a mere hazard made of it, the work falling to the Commission is enormous. Before any scheme is pronounced upon the whole watershed in each case requires investigation. The permits and licences are issued under conditions as to the use of efficient plant and the maintenance of that plant in a high state of efficiency; they provide also for rebuilding, for maintaining a specified system of accounts, and so on. At the end of the period the plant is to be taken over at a valuation, or the permit may be renewed, involving work of a class which the Commission cannot at present undertake. Field forces are necessary for studying the country affected by schemes, and for inspection work in order to ensure compliance with the Commission's terms, but these are all wanting, and the Commission at present is forced to fall back on improvised and borrowed assistance.

All this would hardly appear to give the Commission a fair start in life, but it must not be taken to imply that it is idle. Its first year was largely occupied with formulating rules and regulations but practical results have also been achieved. Up till November 1 of last year, altogether 260 applications had been made to the Commission in connection with power schemes, aggregating some 11,000,000 primary horse-power, or estimated installations of nearly 17,000,000 h.p. They covered 33 States, the District of Columbia and Alaska, and ranged from projects for less than 100 h.p. to the 4,500,000 h.p. scheme for the Colorado River. Altogether 183 of these had advanced sufficiently far for the necessary notice of them to be given by advertisement, while 201 had been referred to field forces of the departments for report, and 98 reports from field forces were received and considered. By November 1 no less than 42 applications had been acted upon, which, all things considered, must be regarded as a good result for a first year with all its preliminary work, and 14 permits and 16 licences had been authorised. The 14 projects involved about 240,000 estimated installed horse-power.

It is to be noted that the Commission deals with hydro-electric schemes only, but in this connection it has power to authorise transmission lines as they are a necessary part of such schemes. A ruling has also been given to the effect that they may deal with steam generating plant if such plant forms part of an hydro-electric scheme and is intended to supplement water power generation in seasons of low supply. But they may not deal with steam plant standing by itself. The title Federal Power Commission is therefore something of a misnomer, for it might be expected that, under such a title, steam and even gas would be included. We have our Electricity Commissioners here, and something in the same style is suggested for our Water resources. Mr. Seabrook recently suggested combining electricity and gas under one set of commissioners. The proposal might be carried further to include water, so that the Board might come to be regarded as the best judge of how all our resources should be utilised to give the maximum service to the country. But if any such organisation is brought into being, let us profit by the example of the Federal Act, and ensure that, once appointed, such a commission would be able to discharge its duties effectively.

EXTENSIONS OF LETTERS PATENT.

IN many cases patentees have to consider at the expiry of their letters patent or some reasonable time before whether it is worth while applying for an extension of the term, particularly having regard to the effect of war conditions. Quite a number of cases have been decided by the courts, and three applications recently reported together usefully serve to show the manner in which applications are considered and more particularly when special provisions are inserted into the extension. Broadly speaking, it appears that if an existing patent is

extended there is no limitation to what is covered by the grant, but if a new patent is issued conditions are inserted protecting others who may have availed themselves of the subject-matter of the patent. The following three cases specifically refer: first, to an application where the patent had not expired but no special agreement was made; second, to a similar application as regards the non-expiry of the patent but accompanied by a verbal agreement; and, third, to an application where the patent had not expired.

In the first case referred to a well-known arrrangement of dynamo-electric machinery came into question. It was found that the invention was meritorious, the remuneration of the petitioners inadequate, and that there was loss by reason of the war. Although it is the practice of the court to insist on detailed accounts properly being supplied to them, and in this instance it was found that the petitioners' accounts required explanation, yet on the whole the learned judge was satisfied that he should grant an extension for four years. The petition was brought both under the Act of 1907 and also under the new Act of 1919, which includes special reference to war conditions, and the court held that the matter could be treated as a proceeding under the later Act. In fact, the petition referred to two patents, and neither of them had expired. For the latter reason no grant of a new patent came into question and therefore none of the special qualifications referred to in the Acts were inserted. The judge held, however, that the extension should be granted on the condition that the British licences which had been arranged should be renewed, if the licensees so desired, on the same terms as at present existing. For the information of inventors it is added that the case followed in the judgment was that of Lawrence and Kennedy's Patent reported in 27 R.P.C., 252, and that case of some years ago may therefore be taken as reasonably showing the basis on which matters of this kind are decided.

The second application for an extension of a patent related to mineral washing and separating apparatus. At the time of the grant the inventor was an engineer in the employ of a certain company with whose consent he had applied for the patent. By a verbal agreement it was agreed between the two parties that the company should have the right to the use of the patent, and that the inventor should be given a commission in addition to his salary. Owing to hostilities there was a large decrease in the plant sold by the company and a consequent decrease in the commission paid to the applicant, so that he definitely suffered a loss thereby. The patentee applied by originating summons under the Act of 1919 for an extension of the patent, and this was granted for a period of four years. As reported in a recent issue of the Reports of Patent, Design and Trade Mark Cases, an application was made on behalf of the Comptroller General that the condition should be imposed that the agreement with the company should be put into writing by a form of deed and registered. The learned judge decided that this should be done on the ground that it should be on record so that other people could have access to the agreement. This case again related to a patent that had not expired, so no special conditions other than the above were provided in the terms of extension.

The third case was in respect of a patent which had expired at the date of the application for extension. The subject-matter related to spring forks for cycles and motor-cycles. Evidence was given that prior to the war there had been a steady increase in the sales of the patented article, but that owing to the war these had decreased to a large extent and the applicants still suffered by reason of hostilities. After some discussion an extension for three and a-half years was granted in place of the five years for which the application was made, but conditions were inserted agreeing to continue previous licences on the same terms as before, and, in addition, the three restrictions provided for in the rules under the new Act were also added. These cover infringements which had taken place after the date on which the patent was announced as void and before its restoration, the use of machines made and the use and sale of articles made during the same period, limited to particular persons and certain provisions in connection with the further use of the machinery in particular buildings.

THE RUBBER RESEARCH ASSOCIATION.

THE British Empire is by far the largest producer of raw rubber, but owing to the way in which enterprise has been fostered in America by an enlightened economic policy, the United States has become by far the largest producer of manufactured rubber, her output being valued, in 1920, at 250,000,000*l.* sterling, out of a total world product estimated at 350,000,000*l.* Three American factories alone produced in that year 100,000,000*l.* worth of rubber goods. With such a turnover, there is little difficulty in persuading shareholders to finance the research work on which the future of every industry depends, though the immediate needs of the moment may, no doubt, be adequately provided for by shop experience.

Our own manufacturers of india-rubber were particularly hard hit by the war, which necessitated the concentration of all their resources on the supply of military stores. This involved the severance of trading connections and the exhaustion of all reserves. Motor car makers were similarly affected, but in that case the danger of the permanent disablement of the industry was recognised and a duty of 33 per cent. placed on imported cars. No corresponding protection was, however, afforded to the rubber manufacturing firms, who have, consequently, suffered very severely from the competition of countries having either the advantage of a depreciated exchange, or that of operating on an enormous scale, and with labour which does not object to the earning of high wages by making a large output. It has further to be noted that many foreign firms dodge our income-tax by supplying their British house at rates which leave no profit on sales. In some foreign countries, this kind of unfair competition is provided against by imposing a tax on the manufacturing profits; the sales company being required to pay a tax based upon the profits of the parent company, and on the proportion their sales bear to the total output.

It is gratifying to note that, in spite of these depressing conditions, a Research Association of British Rubber and Tyre Manufacturers was successfully formed, with the assistance of the Department for Scientific and Industrial Research, and this Association has established laboratories at Lansdown-road, Croydon, where investigations will be undertaken which are either beyond the resources of our (as compared with American) relatively small industrial firms, or which would interfere with the normal routine activities of their laboratories. The premises chosen were originally a pair of detached villas. These have been thoroughly overhauled and enlarged by a new structure, which couples together the two original buildings. The space at the back formerly occupied by the gardens, will afford ample room for further enlargements as the necessity arises. The equipment, in addition to the usual chemical and physical apparatus, includes a fairly complete line of rubber-manufacturing and testing machinery. The steam required for the curing operations and for heating moulds, is supplied by a gas-fired steam boiler designed for a working pressure of 150 lb. per square inch, and made by the Davis Gas Stove Company. A small engineering workshop equipped with a 6-in. lathe, a small shaper, drilling machine, emery grinder, and a forge, will be used to keep the plant in repair, and for the construction of special apparatus. Since some 70 per cent. to 80 per cent. of the raw rubber purchased is made into tyres, an Avery block-testing machine is provided for testing the strength of the fabrics used for pneumatics.

In the United States there are said to be 10½ million motor cars in use, as against a few hundred thousand in this country, so that the American demand for raw rubber is the predominate one. As matters stand, British rubber producers are very far from prosperous, and there is certainly a danger that the planters may be tempted to sell out to America at much below the intrinsic and prospective value of their properties. This would be a serious misfortune, as it seems certain that the present depression cannot be more than temporary. New uses for rubber are being found and the demand must increase.

NOTES.

THE ELECTRICITY SUPPLY BILL.

THE Electricity (Supply) Bill passed its third reading in the House of Commons on Tuesday. It still has to go back to the House of Lords for the consideration of amendments made in the House of Commons, before it receives the Royal Assent. The most important provision of the new Bill lies in the fact that powers are given in it to Electricity Authorities to borrow the money necessary for them to carry out their programmes, and arranges for other necessary transactions. Until now, although provision was made for the constitution of joint electricity authorities, these bodies were unable to act since no powers to raise money had been arranged for. The Government is to be congratulated, therefore, on putting this very necessary finishing touch to an important piece of what promises to be really constructive legislation. The present Bill reduces the whole scheme to a working proposition. When considering the Bill on Tuesday last a number of amendments were taken. These do not affect the main provision of the Bill with regard to financial powers. The most important amendment was one brought in by Mr. Neal, after consultation with the Power Companies' Association and the Association of Municipal Corporations. The amendment had been agreed to by these bodies and, briefly, gave permission to the Electricity Commissioners to exclude from the area of supply of any power company any part of an area in which any right of the company to supply electricity was subject to the veto of another authorised undertaker, and any part of an area not being supplied by the company, but which could be better served by or through the joint electricity authority. This amendment was accepted, as was also one permitting a railway, harbour, tramway or canal company, drawing its supply from a joint electricity authority, to utilise such supply on any part of its system for traction or lighting purposes, whether inside the authority's area or not. Another clause relating to the use of an authority's supply as a stand-by only was also inserted, provision being made for an annual charge in such a case to cover expenditure involved in providing such a stand-by supply. The Report stage being completed, the Bill was read a third time and was carried by 184 votes to 64.

JUBILEE OF THE EASTERN ASSOCIATED TELEGRAPH COMPANIES.

Great Britain has admittedly been pre-eminently responsible for the development of submarine telegraphy, and it is difficult to know which to admire most, the courage of the capitalists and business men who refused to be discouraged by numerous and repeated pioneering failures, or the ability of the engineers and electricians who discovered and remedied the causes. Amongst the former class great credit must be given to the American, Cyrus W. Field; but the men responsible for the technical development and perfecting of the submarine telegraphy were predominantly British. This rule has held from the early days of these undertakings down to the present time, and is mainly attributable to the fact that the cables have remained under private direction and control. This seems to be clearly indicated by the peculiarity that whilst, up to the time the land telegraphs were taken over by the Post Office the majority of the improvements made originated here, the situation was soon rapidly reversed by the blight of nationalisation. Under this drawback Great Britain so far as her land telegraphs were concerned began to import improvements instead of originating them, whilst she nevertheless continued to be responsible for the great majority of the improvements effected in ocean telegraphy, which was company controlled. In commemoration of the fiftieth anniversary of the incorporation of the Eastern Associated Telegraph Companies a banquet was given to some 700 guests at the Royal Botanic Gardens,

Regent's Park, last Monday. In replying to the toast of submarine telegraphy proposed by the Duke of York, the chairman, Sir John Denison-Pender, gave some interesting particulars of the work carried out by the companies since the Armistice. No less than 28,000 miles of new cable have, it appears, been laid since that date at a cost of nearly 12 millions sterling. By this addition the length of line controlled has been brought up to a total of about 130,000 miles, and further extensions are in prospect. In spite of the abnormal increase in working expenses and in the cost of all materials, it was stated that the rates to the general public were not more than in 1914, and, in fact, in some cases had been reduced.

The Law as to Supply of Electrical Energy.

In the case of the Attorney-General at the relation of the Birkdale District Electric Supply Company against the Mayor of Southport, which was decided on Monday last, Mr. Justice Eve was called upon to decide the meaning of the word "supply" in the phrase "to supply electrical energy." So far as we understand the case from the abbreviated report which is available at present, the question arose in this way: The Birkdale District Electric Supply Company apparently had a right, under an Order made under certain Acts of Parliament, to supply electrical energy within Birkdale. The tramways in Birkdale were in a continuous line with those in the borough of Southport, and joined up with them at the boundary between the borough and the urban district. The Corporation of Southport provided the electrical current for driving the cars up to the boundary, and the Birkdale Company provided it beyond that point. In 1911, the Corporation obtained an extension order by virtue of which Birkdale was included in Southport, and the Urban District Council ceased to exist; but for some time the arrangements as to the electric current for the cars were left undisturbed. Recently, however, the Corporation commenced to drive the cars by their own (the Corporation's) electricity over the whole line. The Company considered that this was an infringement of their right to supply electrical energy within the Birkdale district. The question was whether the Corporation, in using their own electricity for the driving of the cars within the Birkdale district, were "supplying" electricity within the meaning of the Company's Order. If there had been no precedent on the point, Mr. Justice Eve would apparently have been inclined to think that they were supplying electricity and so were contravening the Company's rights; but he felt bound to follow the judgment of Mr. Justice North in a water case in 1894, in which Mr. Justice North said: "What is 'supply'? 'Supply' I understand to mean the passing of water from persons who have it to persons who want it. I do not see how it could be said that 'supply of water' means supplying yourselves in the natural meaning of the words." Applying this dictum, Mr. Justice Eve found himself forced to the conclusion that the Corporation, although using electricity for the tramway cars within Birkdale, were not supplying it within the meaning of the Company's Order, and so were not infringing the Company's rights.

Ships' Navigation Lights.

The main object of a Departmental Committee appointed by the Board of Trade on January, 1920, was to consider whether, in order to ensure the compliance of ships' lights with the requirements of the International Collision Regulations, it was desirable to lay down standards for the lights, and, if so, to advise as to those standards and the methods of securing compliance with them. In their report, which has recently been issued, the Committee expresses the opinion that the time is now overdue for the establishment of more precise standards for the navigation lights to be carried on British ships, and recommends that such standards should be enforced as soon as possible. It is recommended, with regard to side lights, that for 5 deg. above and below the horizontal, the light, after passing through the lens and coloured screen, should have an equivalent candle-power of at least 1·6 candles, and that for angles between 5 deg. and 10 deg. above and below the horizontal, the candle-power should not be less than a value which decreases uniformly to the minimum permissible value of 1·6 at 5 deg. to a minimum permissible value of 0·4 at 10 deg. This provision is, of course, intended to ensure adequate visibility when a ship is heeling or pitching. A lens giving the required distribution has been designed at the National Physical Laboratory, and this is dealt with in an appendix to the report. With regard to port and starboard lights, it is recommended that the distinctive colour shall be given to the lights by means of a curved removable screen of coloured glass, shaped so as to fit closely inside the lens and made of 21-oz. glass. The requisite characteristics of coloured glasses are defined, and it is recommended that at least six sets of master standard glasses should be prepared and kept, three at the National Physical Laboratory and three at the Board of Trade. The working standard glasses to be used by Board of Trade surveyors for passing ships' lights would be compared with these standards. The design of lamps, burners, screens and other details for both electric and oil lamps is covered by the recommendations in the report. In the matter of the enforcement of standards the Committee's recommendation, which we regard as a very wise one, is that the responsibility for ensuring that lanterns supplied to ships are in accordance with the prescribed standards, should rest mainly with the manufacturer. To this end it is suggested that the Board of Trade should keep a list of approved manufacturers of standard navigation lanterns, and that lanterns supplied by these firms should be passed without being subjected to individual photometric tests. It is, however, not intended to detract in any way from the responsibilities of the Board of Trade surveyors, and the ultimate decision as to the acceptance or rejection of ships' lights will be in their hands. To avoid subjecting shipowners or manufacturers to unnecessary loss, it is suggested that the recommendations in the report shall only be made compulsory, in the case of new lights supplied to ships, twelve months after public notice of the new requirements has been given, and that all ships' lights shall comply with the requirements within four years from that date. The report, which is obtainable from H.M. Stationery Office, price 1*s.* net, contains some additional recommendations relating to the care and maintenance of ships' lights, &c., and also covers the subject of Morse signalling lamps.

LITERATURE.

Practical Least Squares. By Ora Miner Leland, B.S., C.E., Dean of the College of Engineering and Architecture and the School of Chemistry, University of Minnesota. London and New York: McGraw Hill Book Co., Inc. [Price 15*s.* net.]

The simple application of a method, based on the theory of frequency of error, to the problem of determining the most probable values from a series of necessarily inaccurate measures, does not demand any great mathematical skill or special training. In other words, the application is purely mechanical, an acquaintance with the multiplication table and a capacity for correct addition are the main requirements, and mechanical devices are rapidly supplanting the work of the computer in these particulars. But to arrange the work for the application of the scheme is the work of a master. Great ingenuity and long experience have been devoted to this task, with the view of obtaining the greatest efficiency and reducing to a minimum the arithmetical operations, which can become very onerous, without sacrificing in any way the accuracy of the calculations. It is the main object of the author to exhibit the most convenient plan of conducting the operations involved in the process of the adjustment of observations, and in the application of the method of "least squares" in the solution of normal equations. Very skilfully he has fulfilled his programme, though the banishment of much of the mathematical foundation on which the scheme rests to the limbo of appendices, may be understood to imply, or to insinuate, that engineers are less capable than others of following the theoretical deductions and have to be catered for on inferior lines.

This may be said the more regretfully, because mathematical training aids the due appreciation of some of the elementary principles adopted. In the method of treatment followed, introducing practical methods early and leaving theoretical considerations to a later period, the student is required to accept as truths some statements which are highly controversial, and against which his philosophical soul may revolt. For instance, it is asserted as an axiom that when discordant observations of a single unknown are entitled to equal weight, the arithmetic mean of the several determinations is the best value obtainable from those measures. It must occur to any one to ask, why there should not be some other function than the arithmetic mean which will better satisfy the observations. That the assumption is not axiomatic, or can claim acceptance on the ground of extreme simplicity, is shown by the many attempts that eminent mathematicians have made to furnish a proof of the proposition, while an examination of the literature, with which the author is familiar, tends to show that the principle of the arithmetic mean, regarded either as an axiom or as the result of demonstration is equally untenable. As an illustration of the possible fallacy underlying the assumption, we may quote a remark of Encke's, to the effect, that if the lengths of the perimeters of the inscribed and circumscribed polygons of n sides be considered as two observations of the length of the perimeter of the circle, the arithmetic mean is not the most probable value, in the sense of being the best approximation that can be made. Only if we are justified in assuming that the law of facility of error for each observation is expressed by $e^{-h^2x^2}$ can it be asserted that the arithmetical mean is the most probable result.

Again, as a mere practical matter, is not some qualification necessary to the statement that positive and negative errors of the same magnitude occur with equal frequency in a series of measures. Suppose, for example, the observations were of the reappearance of a star at the Moon's limb. The star could not possibly be seen till it had emerged, and the actual emergence must have anticipated the observation. Other errors will effect the observation, but for this one reason, the recorded time must be too late and give a bias in one direction. Of course it may be urged, that the cause operating in this instance is of the nature of a systematic error, and therefore excluded on the ground that the method is designed for the treatment of accidental errors only. To define an "error," as used in the expression "the Law of Errors of Observation," and in the sense, in which the application of the method of least squares is legitimate, is fortunately not necessary here, but it would have been well to have directed the student's attention more emphatically to the necessary limitations entailed by practical considerations, especially in addressing the inexperienced, who would be apt to grind out a result, whether the device of least squares was applicable or not. The rigorous application of the arithmetical process is the more likely from the skill with which the details are planned, the operations conducted, and the checks arranged that ensure numerical accuracy. The mechanism is so perfect, that thought is eliminated, and the educational value diminished, but a trustworthy result is obtained by adherence to the rules given.

It is no slight task to guide the tyro through the mysteries of the formation of equations of condition, to remove the obscurities connected with weighted observations, to explain the construction and solution of normal equations, to provide independent checks on the accuracy of arithmetic, and finally to produce the values of the unknowns with the smallest possible amount of labour, and with whatever degree of refinement the problem demands. All this the author achieves, and much more, with an ease that would persuade us that no difficulties had been removed by long practice, and that the road was as simple and plain as he makes it appear. We congratulate him on his success. It is conceivable, however, that a novice, equipped only with the rules provided may be held up by the interposition of entanglements that have not been foreseen, for fresh cases bring their own difficulties. It occasionally will happen that the occurrence of inconveniently small divisors prevents a satis-

factory solution of the normal equations by the method of successive substitutions, and many other like abnormal conditions will occur to those, who have done this work. Perhaps individual difficulties can be only satisfactorily met by prolonged experience. We may recall a remark that has been frequently made, to the effect that "it is doubtful if a computer can apply the principles of least squares properly unless he is at least an average observer."

The analysis exhibited and the rules prescribed are generally sufficient for that class of problems known as "conditioned," that is, the class in which the quantities sought are not independent of each other, but have to satisfy certain relations that exist *d priori*. For instance, if the three angles of a plane triangle are all measured, no set of values can be assumed as possible which does not rigorously satisfy the condition, that the sum shall equal 180 deg. Since the computer may meet with fresh difficulties in this class of solutions, rules and examples are provided, founded on practical work, where the adjustment of triangulation and of trigonometrical levelling is rigorously pursued. It would seem possible to pursue this method of forcing an agreement too far, for if pushed to the greatest possible arithmetical accuracy, the conclusions might prevent the detection of physical facts. In geodesy, for example, deformation of the Earth's surface over considerable areas, or slight variations in gravity due to local conditions, might pass unnoticed, but such delicate questions do not generally come under the experimental examination of those for whom this book is written. The treatment of "weights" always an unsatisfactory detail, might have been treated more fully, at least in the early stage. The basis of determination, we are told, is usually the number of observations, and this is apparently the method adopted in the numerical example worked out (page 22). But without any additional explanation, the student would conclude that the accuracy of observation increased as the number of repetitions of measurement rather than as the square root of the number. Of course, this elementary proposition is established subsequently, but the omission is one of the inconveniences of postponing the discussion of the theory. The assignment of "weights" is probably never treated rigorously, being left too much to individual judgment. De Morgan, unhampered by the onerous task of calculation, indicated an improved method but one that borders on a counsel of perfection. He recommended that weights should be assigned as nearly as they can be found, and the most probable result deduced; from this the weights of the equations should be again derived. "If these agree with the assumed weights the process is finished; if not, repeat the process with the new weights, and so on until a result is obtained for which the assumed and deduced weights of the equations are sufficiently near to equality."

Narrowly connected with the subject of weights is that of the legitimacy of rejecting discordant observations, or attaching to them a weight of zero. The remarks made on this vexed question are very pertinent and practical, but the selection of any criterion, whether founded on practice or theory, bristles with difficulties. The observer's judgment of his own observation is an unsafe guide, for experience has shown that he is liable to over-estimate the accuracy of his best observations, while those reported as unsatisfactory are better than he believes them to be. Little improvement has been made in the rough and ready expedient of rejecting any individual observation whose residual from the mean is greater than, say, four times the computed error of a single observation. We gather that the author is not prepared to place great reliance on the more ambitious schemes which mathematicians have derived from the principles of the Calculus of Probabilities, for the criteria proposed by Professor Pierce and others are not discussed. Some of these are false in principle and inadvisable in use. They do not remove the responsibility attaching to the rejection of an apparently discordant observation. It must always be remembered that a proper extension of the method of least squares would go far to reduce the uncertainties attaching to an abnormal observation, by assigning to such a very small value. The calculations as usually performed give, in fact, only the first approximation to the true values, but few of us have the courage to repeat the operations with improved values of the weights.

Mr. Leland's book besides being a very useful guide to the conduct of arithmetical processes treats of many matters that we have been compelled to pass over. Among these may be mentioned the reduction of equations of a higher degree to a linear form, the suggestion of empirical formulæ that might find useful application in the formation of normal places, and the so-called "Propagation of Error." The treatise should be in the hands of every computer who attacks the heavy arithmetical work involved in the application of the method of least squares, for the arrangement of the successive steps is admirable, demonstrates the necessity for a high degree of accuracy, and supplies many models that it would be wise to study and to follow.

Electric Clocks and Chimes. A Practical Handbook giving Complete Instructions for the Making of Successful Electrical Timepieces, Synchronised Clock Systems, and Chiming Mechanism. Illustrated. London: Percival Marshall and Co. [Price 3*s.* 6*d.* net.]

IN this little book, the anonymous author gives very precise instructions for the construction of forms of electric clocks, so precise, that those accustomed to work in metals will probably find little difficulty in following the directions and putting together the several parts of the apparatus. Considered as a parergon, as a useful exercise of constructive ingenuity outside his ordinary *métier*, the amateur should find both instruction and amusement, and if the work is undertaken, as the author recommends, with the view of obtaining a timekeeper that will outrival in accuracy the ordinary regulator, probably some disappointment as well. Much ingenuity and care have been devoted to the task of bringing the weight-driven clock to the accuracy it has attained, and the inexperienced workman, even with the guidance here provided, is hardly likely to gain in one bound the competency that the work of many generations has reached. The self-contained electric clock is subject to the same causes of disturbance that affect the uniformity of rate in the old-fashioned clock; the pendulum will not maintain a constant length because the impulse to overcome friction and other losses is applied differently, and the hope of maintaining "accurate and absolute uniform time all over one's house at a small cost" must not be accepted too rigorously.

Such a result might be attained if it were true "that the ratchet lever driving the works was so arranged that, no matter what the swing of the pendulum be, it pushed one tooth of the ratchet wheel each second." What the ratchet lever does do, or what it is intended to do, is to push forward one tooth of the ratchet wheel, each vibration of the pendulum, and that is not quite the same thing. No doubt the pendulum is adjusted to beat approximate seconds, and the aim is to keep it as nearly as possible to the correct length, but changes in barometric pressure, in temperature, and in hygrometric conditions, will defeat the best intentions. The reference to the "swing of the pendulum." evidently has reference to the "circular error" which inevitably has a variable effect on the rate of the clock. The "swing" in these clocks is usually large, and it might be anticipated that the variation in the voltage of the battery would be more irregular than is produced in either a dead beat or gravity escapement. It is curious, that notwithstanding the meticulous care with which the construction and the assembly of the several parts is described, no mention is made of a scale to measure the length of the pendulum arc.

The author is fully warranted in urging the convenience and the advantages of clocks controlled by some form of electrical action. The chapter by Mr. H. Cook on the mode of working adopted by the Synchronome Company, under the direction of Mr. F. Hope-Jones, is a model of lucidity, and should go far to remove the evil reputation that unfortunately attaches to some forms of electrical control. One cannot get over the inconvenience of waiting an appreciable interval, before the master clock indicates its own time, accompanied as this is by gradually accumulating error. The writer of this notice has had no experience of the Synchronome Company's system, and he may have been unfortunate in regard to the large systems of controlled clocks with which he has been associated, but the annoyance from which he has suffered arises when the controlled pendulum or mechanism gets one beat out. The error remains indefinitely, probably increasing from the operation of the same cause that originated the initial departure, for the controlling apparatus has no means of automatically correcting the error. The form of control which has given the greatest satisfaction, but may only be suitable over short distances, is that in which the bob of the pendulum is formed by a hollow coil of wire, that passes over a permanent magnet at each oscillation, a standard clock transmitting currents which accelerate or retard the motion of the controlled pendulum. In a chapter on a new design for an electrically-driven clock, the author avails himself of the principle, but not of the mechanism, to effect the same object. He suggests a pendulum so constructed that it carries at its lower extremity "a rectangular brass bobbin, properly insulated, and wound with very fine wire, No. 33 gauge. This hollow bobbin, or solenoid, sucks or pulls itself over a rectangular permanent magnet, which is placed horizontally to one side of the clock case." The mechanism described should work as satisfactorily as is possible in an electric clock.

In the last chapter is described a form of striking gear, which can be elaborated to operate a chime mechanism. Some such arrangement has always been regarded as an important function in public timekeepers, but is of less service in domestic clocks to which the author is mainly referring. This chapter is therefore made very short, and rightly, for not only is the source of power separate from the clock, but has no connection with the time circuit. The tune is derived from the passage of a celluloid film, on which the series of chimes are cut in the form of oblong holes spaced according to the length of note, a form that many musical devices have rendered familiar. The gearing appears simple, and there is no reason why it should not be a source of pleasure to those who are in favour of such additions, but as a rule it is unwise to give a clock more work to do than is necessary. Here, however, the connection with the clock is of the slightest.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. By J. W. MELLOR, D.Sc. Vols. I and II. London: Longmans, Green and Co. 1922. [Price 63*s.* per volume.]

THE programme that Dr. Mellor has proposed to himself is one that few would be bold enough to attempt. To give a complete description of all the compounds known in inorganic chemistry, however the term may be limited, and to discuss their formation and behaviour from a physical point of view, would tax the capacity of a committee of scientists, and the task seems beyond the reach of individual effort. The publishers have issued two volumes, each of about 1,000 pages, and anticipate that some four or five further volumes will be necessary to complete the design Dr. Mellor has sketched. This estimate will probably be exceeded, for Dr. Mellor is not content with a mere precis of results, which can be drawn, though not without difficulty, from the original papers published in the proceedings of learned societies and technical journals. He contemplates the production of a work of reference, that shall give not only bald statements of fact, but shall show the mechanism by which scientific knowledge has been acquired. Also by supplying throughout, and especially in the introductory volume, short historical sketches, he increases the interest very materially and helps to preserve a correct perspective in estimating the relative importance of various researches of a like kind. To many students, the names of Black, Priestley, Lavoisier, Dalton and others serve only as a convenient nomenclature for fixing certain so-called laws and theories; the exact grounds on which the reputation of these pioneers rests, or for the varying estimation in which those reputations are held at different periods is a sealed book to many, who have only a superficial acquaintance with chemistry. It is not a small service to bring the students of to-day into closer contact with the greatest minds of the past. Why was a Cannizzaro necessary to make the world appreciate the work of Avogadro,

and how did it give clearness and stability to Dalton's hypothesis, which was well on its way to sterility and possibly oblivion. How is it that Lavoisier's reputation shines brighter now than at any time since he published his "*Traité Elémentaire de Chimie?*" Such questions do not find their answer in a dictionary as that term is generally understood. The term "comprehensive treatise" is quite justifiable.

It is but a small step from the survey of the work of individuals to the utilisation of the combined results attained by many workers in related sciences, for all sciences are connected, each aiding and supporting the other. Physics, whose connection with chemistry was at one time not appreciated or suspected, has established many facts, whose recognition has quickened the progress of chemistry. Electricity, later in time, has given us some hypotheses, valuable but which are hardly dignified by the name of "laws." Crystallography has its own comprehensive generalisations, and has supplied one of the avenues for penetrating the wide subject of molecular mechanism, so important in its relation to physical chemistry. Many other sciences such as optics, magnetism, thermodynamics, might be cited as furnishing some particular link in the ordered classification chemistry hopes to complete. It is right that these related sciences should receive their due mead of recognition, the more so as approach through them permits a clearer insight into chemical operations, and affords an estimate to be formed of the value of the evidence brought to bear on disputed conclusions.

It is easy to indicate some of the lines on which the work is constructed, it is not possible to outline the contents with any degree of completeness. The whole of the scheme is not before us, and it would be premature to decide on the merits of the arrangement from the specimen volumes published. In these, the older chemistry has the prominent place and the atom is considered as the chemists' unit. The mechanism of the atom, its nucleus and electrons the possibility of its disintegration, as foreshadowed in some directions, the existence of isotopes and their separation are not discussed. These topics are reserved for a future volume, more particularly devoted to the consideration of the radio-active elements. Besides preparing the way for the exhibition of the numerous chemical results by the examination of the tools at the command of the chemist, the first volume treats of hydrogen and oxygen and the compounds of these elements, including necessarily ozone and hydrogen peroxide. The second volume begins with the history of fluorine, and treats of the halogens generally and their compounds with hydrogen. The oxides and oxyacids of chlorine, bromine and iodine are also included in this volume, while the larger portion is devoted to the summation of our knowledge concerning the alkali metals. The history of the work effected on the other elements will be arranged mainly in the order suggested by the "periodic law." Whether this is the most logical or the most convenient course can hardly be decided at present. We read of so many laws in this volume, that we cannot doubt but that some will prove to be consequences and will be merged into wider generalisations. Apparently, the author anticipates some such conclusion, for he devotes a section to dissecting the meaning of "law" in the scientific sense, and is careful to explain "that laws do not necessarily establish facts." Of the permanency of the "periodic law" he seems to entertain grave doubts, and hints that it may follow "Bode's law" into the limbo of curious coincidences and ingenious combinations. The principle that the properties of the elements are a periodic function of their atomic weights, may contain an important truth, and amendment rather than oblivion be the fate of one of the most brilliant conceptions chemistry has recorded.

Construction Cost Keeping and Management. A Treatise for Engineers, Contractors and Superintendents engaged in the Management of Engineering Construction. By HALBERT POWERS GILLETTE and RICHARD F. DANA. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 25*s.* net.]

PERHAPS of all the weaknesses of past and even present day works management, the most far-reaching in their influence have been the lack of definite knowledge, in concise form, of the possibilities of output, on the one hand, and, on the other, the treatment of cost records as having book-keeping value only, instead of being an index, and an immediate index, of the efficiency of both workmen, plant and methods. Management in some degree has been a rule-of-thumb business in which practical knowledge of the craft rather than of management has been the controlling factor. In "Construction Cost Keeping and Management," a book of American origin, emanating from the Scientific Management School, the authors are carrying into the sphere of the civil engineer, the principles laid down by Dr. F. W. Taylor, known so well to mechanical engineers on both sides of the Atlantic. Great stress is laid, and deservedly so, on the need by management of knowledge; knowledge of output possibilities; knowledge of achievements; knowledge of production costs with a view to their use for administrative purposes. The field is fairly well covered, and in broad principle the authors strike a right note, although in detail, discrimination is necessary before some of the recommendations put forward could be accepted.

In Chapter I, an attempt is made to define the science of management, and to this end a number of laws are enunciated. While, generally speaking, these are based on a recognition of first principles and cannot be gainsaid, in certain cases, the basis is not so clear, and very careful consideration would appear to be necessary before, for example, the practicability would be assured of "paying men for lost (idle) time not upon the basis of the hourly wage but upon the total hourly earnings (including the average bonus) and place a heavy penalty for lost time upon the man who is responsible for it, at the same time giving him a bonus for reducing lost time below a stated standard." Superficially this sounds all right, but after all, bonuses are paid as remuneration for additional successful effort, and, if additional efforts cannot be expended for some reason, there appears to be no logical ground for paying more than the normal time rate for such periods, nor is there any hardship to the workman should this be done. Many firms in this country have had occasion to rue the day this practice became recognised.

One of the most useful chapters is that of "Measuring the Output of Workmen." There can be no doubt that an accurate knowledge of the possibilities of output is one of the most important requirements of management. Such knowledge lifts questions concerning output out of the realm of opinion; opinion can but reflect comparison, and this in turn is based on experience, without reliable information as to whether the practice on which it has been built was efficient or otherwise. Definite knowledge, as to the amount of work which can be done, under known circumstances, and in a given time, is most desirable, and enables a standard to be set which is independent and superior to "past records." W. A. Gillette's method of estimating excavation yardage daily, however, although having some value, would appear to be a record of output under a special form of supervision rather than a measure of output.

Cost-Keeping, Chapter V, is dealt with as an aid to management. Whether cost-keeping records should be kept distinct from book-keeping records, may remain an open question, but, while costs are necessary for book-keeping purposes, they have a value to management which can hardly be over-estimated, a fact to which mechanical as well as civil engineers might give greater prominence. It is quite common to find costs presented long after the whole of the work has been completed, too late for any remedial measures to be applied. Under the control of the engineers, such presentation should, as required by the authors, be made daily, and, for many classes of work, this does not appear impossible or impracticable. Costs so rendered can be used as the most efficient check on output and estimate conceivable.

The remainder of the book is given up to descriptions of the various systems of payment by results, and of the systems and methods of cost-keeping; numerous illustrations of the forms used are given while the various mechanical appliances available are described and illustrated. There is a chapter on "Book-keeping for the Small Contractor," and another on the keeping of costs of highway construction. In places the book may be found somewhat pedantic in tone; the terms used are different to those in use in this country; the number of forms given appears to be unnecessarily large, but to the discriminating reader, there is much food for thought, and the book is one which we think every contractor would find of real use.

BOOKS RECEIVED.

The Motor Car Index, 1922. Compiled by J. F. ATKINSON. London: The Motor Car Index. [Price 10*s.* 6*d.*]

Aeronautical Research Committee. Reports and Memoranda. No. 681. *A Consideration of Airscrew Theory in the Light of Data derived from an Experimental Investigation of the Distribution of Pressure over the Entire Surface of an Airscrew Blade, and also over Aerofoils of Appropriate Shapes.* By A. FAGE, A.R.C.Sc., D.I.C., and R. G. HOWARD, B.Sc., A.M.I.C.E. [Price 3*s.* 2½*d.* post free.] No. 761. *Experimental Determination of Tailplane Characteristics.* By H. GLAUERT and I. L. PEATFIELD. [Price 10*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

The National Physical Laboratory. Report for the Year 1921. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 6*s.* 6*d.* net.]

United States Bureau of Labour Statistics. Bulletin No. 301. *Comparison of Workmen's Compensation Insurance and Administration.* By CARL HOOKSTADT. [Price 20 cents.] No. 306: *Occupation Hazards and Diagnostic Signs. A Guide to Impairments to be looked for in Hazardous Occupations.* By LOUIS J. DUBLIN, Ph.D. and PHILIP LEIBOFF. [Price 5 cents.] Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 200. *Evaporation Loss of Petroleum in the Mid-Continent Field.* By J. H. WIGGINS. [Price 20 cents.] No. 207: *The Analytical Distillation of Petroleum and Its Products.* By E. W. DEAN and others. [Price 15 cents.] Technical Paper, No. 268: *Preparation and Uses of Tar and Its Simple Crude Derivatives.* By W. W. ODELL. [Price 15 cents.] No. 298: *Methods for Testing Petroleum Products; A Handbook for Inspecting Laboratories.* [Price 10 cents.] Washington: Government Printing Office.

Aeronautical Research Committee. Reports and Memoranda, No. 763: *Lift and Drag of B.E. 2.E., with R.A.F.19 Wings. Comparison of Full Scale and Model Results.* By H. M. GARNER and F. B. BRADFIELD. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 1*d.* post free.]

Report of the Aeronautical Research Committee for the Year 1921-22. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 2*s.* 7½*d.* post free.]

Commission of Inquiry into the Resources and Industries of Ireland. Report on Water Power, January, 1922. Dublin: Offices of the Commission. [Price 2*s.* 9*d.* post free.]

The Journal of the Institute of Metals. Vol. XXVII., 1922. Edited by G. SHAW SCOTT, M.Sc. London: Institute of Metals. [Price 31*s.* 6*d.* net.]

Mechanics. Part I. By GEORGE THOMPSON and GEORGE H. LESLIE, B.Sc. London: Cassell and Co., Limited. [Price 2*s.* net.]

Proceedings of the Rugby Engineering Society. Vol. XIV. Session 1919-20. Rugby: Published by the Society.

The Water Supply Problem of Philadelphia. Philadelphia: Bureau of Municipal Research.

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1922. London: The Directory Publishing Company, Limited. [Price 20*s.* net.]

Petrol Cars and Lorries. Describing Clearly and Concisely the Construction and Operation of Modern Petrol Vehicles. For Owners, Drivers, Mechanics and Students. By FRANK HEAP. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

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Notes and Sketches on Marine Diesel Engines. A Manual of Marine Oil Engine Practice. By J. W. M. SOTHERN, M.I.E.S., M.I. Mar.E. Glasgow: James Munro and Co., Limited. [Price 25*s.* net.]

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G. H. BRYAN, Sc.D. [Price 10*d.* post free.] No. 757: *The Effect of Rate of Loading on the Apparent Strength of Cotton Balloon Fabric.* By GUY BARR, B.A., D.Sc. [Price 4½*d.* post free.] No. 770: *The Drag Curve of R.A.F.14 B.E.2.E. Wings Obtained by Full Scale Experiments with Airscrew Running and with Airscrew Stationary.* By the Aerodynamics Staff of the Royal Aircraft Establishment. [Price 4½*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

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Trockene Kokskühlung mit Verwertung der Koksglut. VON L. LEITNSKY. Leipzig: Otto Spamer. [Price 120 marks.]

Capstan and Automatic Lathes. A Practical Guide to Tool and Machine Setting. By PHILIP GATES. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Coal in International Trade. By A. J. SARGENT, M.A. London: P. S. King and Son, Ltd. [Price 2*s.* 6*d.* net.]

Magnetism and Electricity. By J. Paley Yorke, M.Sc., A.M.I.E.E. London: Edward Arnold and Co. [Price 5*s.* net.]

Steel Thermal Treatment. By JOHN W. URQUHART. London: Crosby Lockwood and Son. [Price 35*s.* net.]

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A Note on the Legibility of Printed Matter, Prepared for the Information of the Committee on Type Faces. By LUCIEN ALPHONSE LEGROS, O.B.E., M.Inst.C.E. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

Report of the Committee Appointed to Select the Best Faces of Type and Modes of Display for Government Printing. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 4*s.* net.]

The Engineering Workshop Handbook for Fitters, Turners and General Machinists. By ERNEST PULL, A.M.I. Mech.E., M.I.M.E., R.N.R. Fifth Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 3*s.* 6*d.* net.]

Elementary Hydraulics; For Technical Students. By PROFESSOR F. C. LEA, D.Sc., A.R.C.Sc., M.Inst.C.E., M.I.Mech.E. London: Edward Arnold and Co. [Price 7*s.* 6*d.* net.]

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INFLAMMABILITY OF COAL DUST.

WITHIN the last few decades miners and chemists have become more and more convinced that the factor which makes some mine explosions so terrific is not so much the methane gas as the fine coal dust stirred up by an originally minor explosion of methane.

Modern intense coal-getting methods have increased the production of fine coal dust and have thus counteracted the better provisions for safety secured by the insistance on the exclusive use of safety lamps in mines and by the better ventilation of the latter. A hundred years and more ago, when mining operations were carried on more leisurely, coal mine explosions were sufficiently frequent to make Humphrey Davy take up the problem of the safety lamp; yet they were comparatively less disastrous. The workings were less extensive, there were fewer men, and less fine dust was produced. Such dust now enables the explosive wave to travel on in the spacious straight galleries and to gain in speed; the mechanical destruction is thus increased, more carbon monoxide is produced by the incomplete combustion of the dust, and the spreading of this gas kills the men whom the explosion left alive.

The probable guilt of the coal dust, which miners have learnt to render harmless by wetting it, or, better still, by spreading incombustible and non-gritty stone dust (slate) on it, seems to be obvious. Everybody knows that any combustible substance, even iron, will flash up when finely powdered and ignited. The first disastrous factory explosions were indeed observed in flour and sugar mills, and of late explosions of aluminium and zinc dust have become sadly frequent. Although powdered aluminium certainly does not give off appreciable volumes of gases, and flour is hardly likely to do so, some chemists and mining men have suggested that the coal-dust particles need not directly unite with the oxygen of the air, but might be sufficiently heated by a spark or flame or by contact with hot bodies to set up an instantaneous distillation of gas which would envelop each dust particle and propagate the flame from one particle to another. That view received support by the discordant results of various experiments, in some of which sparks and hot bodies failed to ignite coal dust. Although the inflammability of gases and vapours displayed similar peculiarities to an extent that renders the definition of their "ignition points" meaningless except when referred to particular local conditions, the question of the more or less ready liberation of gases from coal dust is certainly of interest. That anthracite dust will not propagate an explosion under conditions when dust of lignite or bituminous coal will, does not prove that coal dust is, as such, in the absence of gases, incombustible. Most people now consider that coal dust is itself explosive; the small quantity of gas evolved from a very small portion of the dust during a small fraction of a second, say 0·01 second, can at any rate not play an important part. But that portion of gas may be additional to other gas which had been slowly accumulating on the coal particles. Hence the summary of recent work on the subject, by the United States Bureau of Mines, published by Guy B. Taylor, Horace C. Porter and E. C. White under the (hardly commendable) title, "Momentary Heating of Inflammable Coal Dusts," deserves attention.

An appliance used in this connection is shown in Figs. 1 and 2. A glazed silica tube *a* is set with plaster of Paris in a brass socket screwed to the brass dust-proof lock chamber *b*; a lead gasket makes the joint gastight.

Fig. 1.

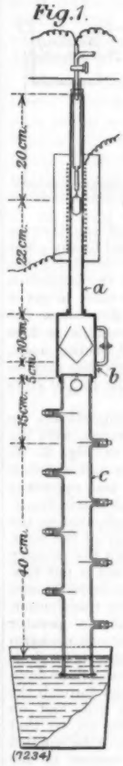
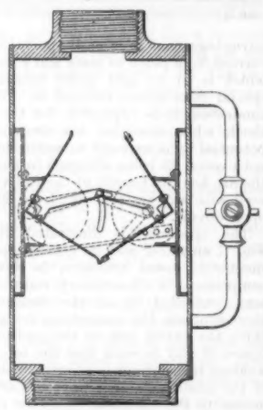


Fig. 2.



The glass tube *c* is fastened to the chamber in a similar manner, but a fibre gasket is used to facilitate the disconnection of the union. The hot body is a solid cylinder of monel metal, pointed at its lower end and suspended by the aid of a loop and of an eyehole, within an electric furnace, heating the body, of 70 grammes weight, up to 1,100 deg. C. The loop holding the body is fused by the current to release the weight. The electric connections are established with the aid of a rubber stopper (in the silica tube) through which pass a silica tube for the thermocouple, a glass tube and other parts supporting the wire loop. To prevent any dust from penetrating into the hot silica tube, the weight is made to fall through a locking device opening one pair of gates and closing another immediately behind it (Fig. 2). The upper and lower gates on each side are made in one piece. When the weight strikes the lower leaves, a powerful spring snaps the upper leaves tightly together; opening the lower leaves to a fraction of a centimetre actuates the spring so that the resistance to the fall of the weight is very small and the gate shuts before the weight leaves the lock. Asbestos wipers further help to make the device dust-proof.

As it is difficult to ensure that the weight falls through a cloud of known and uniform density, various devices have been tried by experimenters to raise a cloud by a puff of air. In the Pittsburgh apparatus shown by Fig. 1 the glass tube of 53 mm. diameter is provided with eight ports by sealing small glass tubes alternately in each side. Each tube is closed by a rubber stopper carrying a narrow strip of copper and on it a pile of dust; the falling weight strikes these strips successively after which they spring back, the weight falling into a water bucket. In most of the experiments the weight fell 32 cm. before striking the gate, 52 cm. before striking the first strip and 92 cm. to the water surface. The theoretical period of unobstructed fall through the dust zone would have been 0·11 second. It was found that with no other obstruction but the gate and vanes Pittsburgh bituminous coal dust did not always inflame. To insure inflammation with the lock used, it was necessary to insert a light obstruction in the path of the hot weight. For this purpose a small ball of lead, 15 mm. in diameter, was suspended on a fine glass rod across the lower end of the lock box (Fig. 1). The falling weight breaks this rod and carries the check-weight with it. In other experiments also inflammation was always obtained when the body travelled more slowly; a minimum time of about 0·20 second seemed to be required. In some experiments the cloud was preformed. In addition to Pittsburgh and other coals, dextrine, and corn and wheat starch were inflamed.

These experiments were made in an atmosphere of air. In order to determine the gases qualitatively and quantitatively the apparatus was charged with nitrogen to which measured percentages of oxygen could be added. The gas evolution then observed was always small and, oddly enough, the main constituent of the gas found, even in atmospheres of nitrogen only, was not some hydrocarbon, but carbon monoxide. In ordinary distillation CO is, of course, not the main gas evolved. There must have been some source of oxygen; air could not altogether be excluded, aqueous vapour was always present, and some oxygen might have been derived from the oxide scale on the monel metal. The report to which we refer does not mention oxygen occluded by the coal which might certainly play a part. In any case, however, about 1 gramme of coal gave only a few cubic centimetres (1 to 3) of gas, a very small amount. It is noteworthy that a brownish tar mist was also observed in experiments with hot bodies, but not when the body was kept cold.

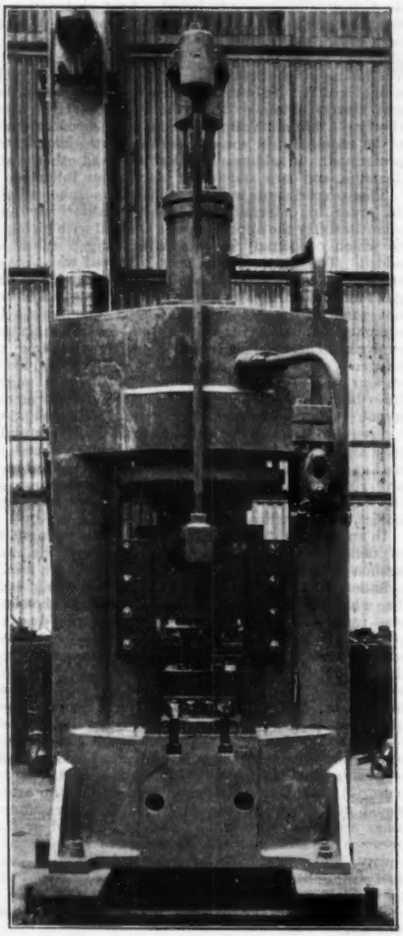
In another series of experiments a blast of nitrogen or of definite nitrogen-oxygen mixtures was directed against a sample of coal dust placed within a small cylinder of alundum surrounded by a heating coil. The whole was placed in a wide glass tube, and the blast was turned on 2 seconds after putting the dust in position in the tube which had previously been filled with the respective gas mixture. In this case long flames (2½ ft.) were sometimes observed; but the length of the flame bore no relation to the inflammability of the coal, nor did apparently the quantity and quality of the gas evolved. Finally, G. A. Hulett tried to induce explosion by an explosive agent not containing oxygen, hydrogen or carbon, namely, lead azide, which is a substitute for mercury fulminate, and a very powerful detonator. Coal dust mixed with the azide would not propagate the explosion, however; under other conditions powerful explosions occurred in the presence of air. But the results were again inconclusive, and when hydrogen was added to the coal dust atmosphere, the experimenters expected that all the available oxygen would combine with the hydrogen; that it would not do so, has been proved by Bone long ago.

Thus the general conclusion drawn is that coal-dust suspensions are inflammable in air under conditions under which predistillation of gas can hardly be an effective factor in producing ignition. We may then assume that the oxygen attacks the coal directly, and that the probability of an explosion is increased by increasing fineness of the coal-dust particles. In the experiments mentioned some of the dusts were passed through 200 mesh. Coal dust is, as we said, certainly explosive in the sense that any combustible dust is explosive. The experiments we have noticed do not settle the question of the possible intervention of gases predistilled by the ignition heat. So far as mine explosions are concerned that question is of little importance, however, and experiments on small scale, such as conducted at Pittsburgh and in various other ways elsewhere, cannot be considered promising.

THE CRYSTAL PALACE SCHOOL OF ENGINEERING.—Major-Gen. Sir G. K. Scott Moncrieff presided on Wednesday at the summer term certificate distribution of the Crystal Palace School of Engineering. The school's certificate of honour was awarded to Mr. W. H. Butler. Sir Scott Moncrieff said one of the great attractions of the engineering profession was that it was continually progressing. It was a profession of achievements. He knew of no greater source of gratification than in seeing in use work completed from designs from one's own brain; the triumph of mind over matter. Sir Scott then gave the students some practical suggestions gained by him in his wide experience—planning, materials, structural design, work's method and counting the cost.

CHAIN LINK PUNCHING PRESS.

In the figure below we illustrate a heavy punching press specially designed for punching out the side links of bucket dredger chains. This press will punch out to correct shape the two ends of a link in one operation, and is capable of dealing with metal bar 3 in. wide by 1¼ in. thick. The machine is part of an order executed by Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham, for the Butterley Company, of Derby, who manufacture dredger buckets and other heavy conveyor work. The complete order included, among other items, horizontal pumps,



an accumulator, a bending press taking plates up to 6 ft. wide, and an horizontal press for bending angles, bars and rolled sections, &c.

In the press illustrated the main ram moves downward on the working stroke, with the slide and punch, the work remaining stationary. The guides are machined in the solid casting. The slide is very massive, and an automatic auxiliary ram with crosshead, arranged above the main cylinder withdraws the slide on the completion of the working stroke. An automatic stripper is provided, while the punchings can fall clear of the bolster so that there is no fear of choking. The length of the links cut can be regulated by an adjustable stop. This enables the operator, by feeding up against the stop, to repeat links of the same length as fast as the finished ones can be cleared. The press is also, of course, adaptable to other work with suitable dies, &c.

Special care has been taken to ensure accessibility of parts so that the tools can be quickly changed.

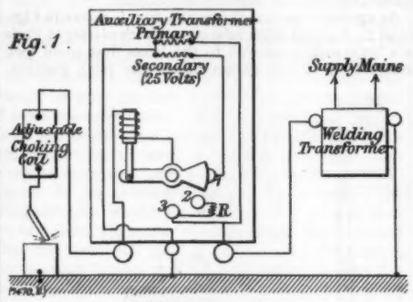
ROYAL AERONAUTICAL SOCIETY.—At a council meeting held on the 18th instant, it was decided to award the Society's silver medal for 1921 to Mr. H. R. Ricardo for his paper entitled "Some Possible Lines of Development in Aircraft Engines." This paper was read at a meeting held on December 16, 1920, and was reproduced in ENGINEERING, vol. cxi., on pages 28 and 57. In future, the silver medal will be awarded annually to the author of the paper which, in the opinion of the Council, is the best of those published in the Society's Journal during the year.

SAFETY DEVICE FOR ARC WELDING.

In a memorandum on arc welding, issued by the Factory Department of the Home Office about a year ago, reference was made to the special risks from shock to men engaged in welding work inside boilers, or in shipbuilding, owing to the operator being in contact with earthed metallic surfaces. Attention was also called to the fact that, in the case of men working on stagings, a slight momentary shock, insufficient of itself to be injurious, might cause a man to fall off the staging, with serious results. It was recommended that in all such cases, direct current only should be used for welding, or if alternating current were employed, special precautions should be taken to protect the operators from shock.

A simple device which can be used in connection with any alternating-current welding system, and which appears to provide the necessary protection for operators, has recently been designed and constructed by Messrs. Davies and Soames, of 66, Southampton-row, Holborn, W.C.1. This device has the important

Fig. 1.



advantage that it is easily portable, and can thus be carried from place to place and connected to any plant which is to be used under conditions involving the special risks above referred to. With the apparatus connected, it is impossible for the operator to get a shock when changing his electrode, &c., since the potential he is exposed to under these conditions does not exceed 25 volts, although in normal welding work, the arc has the benefit of the full voltage that may be used with any system, viz., from 80 volts to 110 volts open circuit.

The apparatus is illustrated diagrammatically in Fig. 1, annexed, and its general appearance, with the sheet-steel cover removed, is shown in Fig. 2. It comprises a small auxiliary transformer and a switch arm controlled by an electromagnet, and operating three contacts, the connections being as shown in Fig. 1. With the switch arm in the position indicated in the figure, it will be seen that the secondary of the main welding transformer is connected through the primary of the auxiliary transformer to earth, and is not connected to the electrode. Current to the latter is supplied from the secondary of the auxiliary transformer, which is wound for 25 volts, so that if the operator touches the electrode under these conditions no harm can possibly result. When, however, the electrode is brought into contact with the work, current flows from the secondary of the auxiliary transformer through the electro-magnet, and moves the switch arm first on to the contact numbered 2 and finally on to that numbered 3, when the full voltage will be applied across the arc less the drop which occurs in the adjustable choking coil, if such is employed. Welding can then be carried on in the usual way, but as soon as the electrode is moved from the work for a sufficient distance to break the arc, the switch arm returns immediately to its original position on contact 1, thus putting the electrode across the secondary of the auxiliary transformer and again reducing the potential to 25 volts.

The object of the intermediate contact 2 and the resistance R connected between the contacts 2 and 3, will be apparent from a consideration of the connections shown in Fig. 1. It will be seen that if the contacts 1 and 3 were directly connected by the switch arm in passing from one to the other, the secondary of the welding transformer would be earthed momentarily through the low resistance secondary winding of the auxiliary transformer. Any damage which might possibly arise from this circumstance is, however, entirely avoided in the arrangement adopted, since when the switch arm bridges the contacts 1 and 2, the resistance R is connected in series between the transformer secondaries, thus limiting the current flow to earth. In any case, the connection to earth is only maintained for a very small fraction of a second, further movement of the switch arm disconnecting the secondary of the auxiliary transformer, short circuiting the resistance R and connecting the electrode to the secondary of the welding transformer as previously explained. It will be noticed that the primary of the auxiliary transformer remains connected to the welding transformer secondary in all positions of the switch arm, so that the small magnetising current in the former is always maintained.

As will be gathered from an examination of Fig. 2, the arrangement of the actual apparatus differs somewhat from that shown diagrammatically in Fig. 1. In Fig. 2 the auxiliary transformer is mounted on the back of the panel and cannot, therefore, be seen, but the switch arm, it will be noticed, is pivoted on a bracket near its upper end and suspended in front of the core of the electro-magnet. The main contact, which carries the welding current, is formed by a thick copper tube screwed on to the switch arm, the tube engaging with

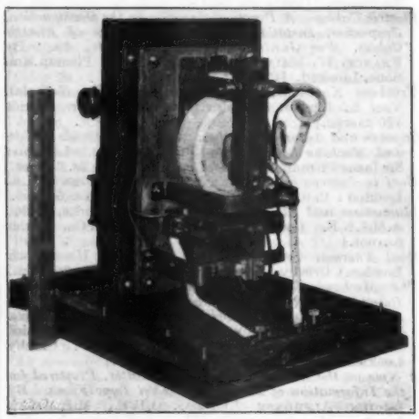


FIG. 2.

the prongs of a pair of fixed copper combs when the magnet is energised. It is perhaps hardly necessary to point out that no trouble is likely to be experienced with this contact, owing to the fact that the circuit is actually made and broken between the electrode and the work. The other two contacts are of the carbon, block type, and are carried by a horizontal bar attached to the lower end of the switch arm. They are, of course, arranged to make and break the circuits in the sequence explained above. We recently witnessed a demonstration of the working of the apparatus, which was entirely satisfactory in every way, although it was attended by a certain amount of noise. This latter feature, however, is by no means a drawback, since it would serve to inform the operator, who might be working inside a boiler, that the apparatus was functioning normally.

"THE JOURNAL OF THE INSTITUTE OF METALS."—This volume, which covers the proceedings at the last Spring meeting of the Institute, deals with practical problems relating to the corrosion, protection and season cracking of condenser tubes, failure of aluminium alloys, gold bullion assay, re-crystallisation of cupro-nickel and other metals; it also gives the address by the new President, Mr. Leonard Sumner, O.B.E., M.Sc., pointing out the value of the Institute from the manufacturer's point of view, and urging the need for manufacturers in the non-ferrous metal industries to support the work of the Institute. The volume concludes with abstracts, these being concise summaries of metallurgical papers that have been published in all parts of the world during the past few months. The book can be obtained from the Institute, 36, Victoria-street, S.W. 1, or from any bookseller, price 31*s.* 6*d.* net.

INTERNATIONAL AIR CONGRESS, 1923.—It is proposed to hold in London, in June, 1923, an International Air Congress similar to that held in Paris last November. H.R.H. the Duke of York has consented to become President of the General Council of the Congress, and Lord Weir has accepted the invitation to become a Vice-President. A strong organising committee representative of all phases of aeronautical activity has been formed, and the Congress will be open to all countries which are signatories of the International Air Convention, or are represented on the Fédération Aëronautique Internationale. According to present arrangements, the Congress will occupy one week during the last fortnight of June of next year, alternate days being devoted to the reading and discussion of papers and visits to aeronautical establishments. It is perhaps necessary to point out that the proposed Congress should not be confused with the Air Conference called each year by the Air Ministry, which deals with aeronautical matters only so far as the British Empire is concerned. The Congress now announced is essentially of an international character, and is intended to form one of a series to be held in various countries. Lieut.-Col. W. Lockwood Marsh, the Secretary of the Royal Aeronautical Society, 7, Albemarle-street, W.1, is technical secretary to the Congress.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 86.)

Physics Department.—The divisions on Heat, Thermometry, Radiology and Sound have been grouped under the administrative direction of Dr. G. W. C. Kaye, M.A. We have already referred to the intended erection of a Physics Building; so far only a central office exists.

Heat Division. (Dr. Kaye, Dr. Ezer Griffiths, Messrs. F. H. Schofield and A. H. Davis.) *Pyrometers.*—The ordinary test work has been normal, the calibration of optical pyrometers being the heaviest item. The Laboratory optical pyrometers of the disappearing filament type have been illustrated by us; both Messrs. Tinsley and the Cambridge and Paul Instrument Company are, by permission, utilising the novel features in their instruments. The Laboratory standard pyrometer of this type was made in the Laboratory, but it is fitted with a lamp obtained from the United States Bureau of Standards. This lamp is a short cylinder of glass, closed at both ends by mechanically-flat plates of glass fused to the cylinder; the evacuated space inside contains a horse-shoe filament provided with a small kink which serves as reference point. The intensity of the source is diminished by the aid of a rotating sector. The varied research work has assumed very wide dimensions.

Heat Transmission through Building Materials. Porosity.—The materials tested are typical walls, 9 ft. square, of standard thickness, plasters for surfacing the walls (made in blocks 12 in. by 12 in. by 2 in.) and combinations of these two. The walls were horizontal or vertical and consisted of stocks in cement, sand lime in cement, flettons and coke breeze in cements, and also of weather boarding; the plasters consisted of cement with sand, chalk, granite and coke breeze, of Portland stone and Roman mortar. The thermal conductivities, in British thermal units, per square foot per inch thickness and 1 deg. F. temperature difference ranged from 2·2 (a plaster of 20 chalk, 1 cement) up to 9·3 (sand lime in cement).

For the porosity tests, blocks, 2 ft. square, 4½ in. thick, were made of fletton and stock bricks, concrete (ordinary or rammed) and coke breeze (ordinary and rendered), and the pressure differences on the two sides were determined when gases were drawn through the blocks. The gases were air, coal gas and carbon dioxide; the CO_2 was tried with special regard to fruit preservation, and this gas was absorbed by coke breeze to such an extent as to frustrate measurements. Otherwise the rate of flow of gas proved approximately proportional to the gas pressure for ranges from 16·7 lb. up to 80 lb. per square foot; 100 lb. per square foot was the maximum pressure difference observed. Experiments with hydrogen further confirmed the conclusion that the rate of flow depends upon the viscosity of the gas.

Some plaster slabs tried were smooth over one half the surface, and rough over the other half; the rough surface then proved the more porous, probably owing to surface condensation, the relative porosity figures for lime plaster being 10·7 and 3·4, except in materials of very low porosity (cement and sand sirapite, average porosities 0·022 and 0·048). These relative porosities are expressed in cubic feet of gas passing per hour through 1 ft. thickness under a pressure difference of 1 lb. per square foot. When a lime plaster was covered with a common glazed wall paper, the porosity coefficients were: Without paper, 7·2; with paper, 6·2; with varnished paper, 4·3. As regards the surface condensation of moisture (in steamy atmospheres) remarkable differences were observed; extra-smooth surfaces became covered with a continuous film of moisture, whilst there was very little deposit on rough surfaces; lime plaster with 10 per cent. of cement retained most moisture and sirapite least. Ordinary lining paper became soaked, distemper surfaces showed a moderate deposit; but the visibility test may be misleading because pores and rough surfaces hide the deposit.

Thermal Conductivity. Latent Heat. Liquids. (Dr. Griffiths and Mr. Davis.)—The liquid is placed within a silver tube, 2 mm. in diameter, in which an axial, 3-mil. platinum wire is stretched; an electric current is passed through the wire, and the current is measured which will maintain a given temperature difference between the wire and the tube; a bridge arrangement is used. The conductivities observed at 15 deg. C. were in 10^{-4} c.g.s. unit: Aniline 4·1, ethyl alcohol 4·5, carbon tetrachloride 2·7, figures which agree with those of the absolute method. In the determination of the heat convection of transformer oils, vertical pipes, several feet high, are connected by cross pipes so as to form a rectangular conduit, through which the oil circulates. In the one pipe the oil is heated by an electric coil, in the other it is cooled by a brine coil; the temperature of the hot coil, the rise at the top of the hot column and the velocity of flow are determined for the calculations.

For the determination of the latent heat of evaporation of liquids of high boiling points the liquid is placed in a glass vessel provided with a vacuum jacket; this vessel is immersed in a tank (fitted with glass windows) containing oil which is kept at exactly the same temperature as the liquid. The vapour from the liquid is carried through a tube (kept hotter by a heating coil to avoid premature condensation) to a condenser; from the electric input and the amount of vapour condensed both the total heat and the latent heat can be deduced.

Thermal Conductivity of Metals at High Temperatures. Insulating Materials.—Two sections of a pure metal rod, 1·2 cm. in diameter, each 75 cm. long, are fitted into one another with an overlapping joint. Each of the inner ends has previously been provided with a central axial bore, 4 cm. long, so that there is a hollow, 8 cm. long, in the middle of the joined rods; into this hollow fits a heating coil wound on a silica strip and insulated on the outside by mica and asbestos wool. By the coil a steady flow of heat is maintained from the centre towards both the ends of the rod. Heat loss from the rod surface is prevented by jacketing the rod with a copper sheath kept at the temperature of the corresponding points of the rod, this being controlled by thermocouples. So far copper has been tested at temperatures up to 500 deg. C.

For the determination of the thermal conductivity of thin sheets of metal, wood, and insulating materials, from 1 mil. up to 0·1 in. in thickness, a different arrangement is adopted. Two sheets of the specimen are used; between them is placed the electric heater plate, sandwiched between two insulating sheets of mica; outside of the mica are two copper discs, which serve as hot faces. The whole system described is wedged in between two copper blocks, one above, one below, and is packed with asbestos wool. The copper blocks, which are cooled by coils, constitute the cold faces, and differential thermocouples are inserted between each disc and the respective copper block. The heat, it will be understood, travels from the heater plate, both up and down, through a mica sheet, a disc, and a specimen, to a block. The block faces have accurately to be planed, and they are amalgamated to secure good contact. The blocks can be loaded during the test.

Most of these investigations, by Dr. Griffiths and Mr. Davis, as well as those on Heat Radiation and Convection, especially to be noticed, are being conducted for the British Industries Research Association or the Department of Scientific and Industrial Research. A private research of this kind concerned the specific and latent heats of the materials used in chocolate manufacture, cocoa powder and cocoa butter; the difficulty—the tendency of the materials to cake—was overcome by using a calorimeter the plate heaters of which were attached to a rotating stirrer.

Balsa Wood.—The Brazilian balsa wood, new to this country, is a very promising insulating material. It looks like poplar wood and is exceedingly light and soft and more easily handled than cork; the wood has to be treated with some preservative.

Air Temperature Determination.—Two thermo-electric devices for taking gas temperature require mention. The one is a multiple thermocouple designed in conjunction with the Instrument Section of the Air Ministry to measure temperature differences between the gas in the ballonets and the atmosphere within 0·2 deg. C. A difference of 3 deg. would, for the airship in question, have meant a change in the lift of 1 ton. The points at which the temperatures were to be determined were 80 ft. apart. The couple used consists of six copper-constantan junctions joined to a Cambridge direct-reading millivoltmeter; the outside diameter of the cable is 1 cm., and the compact outfit, not requiring a battery, has proved very satisfactory.

The other outfit was made for the Indian Survey Department which desired accurate information about the distribution of temperature within 150 ft. of the Earth's surface in order to correct for atmospheric refraction. A robust portable mast was suggested. As thermocouples with sensitive galvanometers and Callender resistance thermometers with compensating leads would have been too cumbersome, it was decided to place a number of resistance thermometers in series with a standard resistance of manganin. A constant current is maintained in the circuit, and the drop in volts over each thermometer is measured in turn by means of a selector switch and a potentiometer. The platinum resistance strips are wound on micanite pillars held by cast iron frames; each of the 10 thermometers is 14 ft. long or high, and their total weight is 50 lb.

Lowering the Temperature of Fruit Stores.—We have mentioned the researches of Dr. Kidd, of Cambridge, on fruit storage. Dr. Kidd noticed that some circulation of air could be maintained in such stores simply by fixing a ventilating duct or pipe on the outside of the store; during the night the air in this duct was cooled, and in sinking, sucked air from the store downward with it. In trying to improve this method Dr. Griffiths has constructed a small hut, 6 ft. cube, of sheet iron and cork. A zinc tube, about 3 in. diameter, runs up the one outside wall, and enters the hut near the top in two equal horizontal branches, into the mouth of one of which a fan is fitted. Below the duct also enters the hut and terminates in a "flared" end, a horizontal mouth of the same opening as the other branches. Air can thus circulate through the pipe and the hut by natural or by forced (fan) ventilation. It has been found that the temperature in the hut can be effectually lowered simply by wrapping the pipe with wetted cloth, on the wet-bulb thermometer plan, and experiments are being made on the relative cooling effects of ventilating currents of different speeds.

Thermometry Division. (Messrs. W. F. Higgins and W. Hugo.)—The equipment of this department has not been added to. The number of Class A thermometers dealt with has increased to 1,378. The Dial instruments submitted for tests have improved, and an accuracy of 0·5 per cent. is obtainable; the indications are frequently not the same, however, with rising and falling temperatures, and correctness within 0·1 per cent. might be obtained. The Powell blue-strip glass compares very well with the Jena 16III glass. The number of B Class thermometers sent in for test has decreased, and that of clinical thermometers still more, viz., 1,597,339 in 1920 and 879,897 in the year ending September 30, 1921; we referred to the reason in our introduction—thermometers for export need no longer be tested.

Radiology Division. (Dr. Kaye, Dr. E. A. Owen, Miss P. K. Bowes, M.A., Miss B. Naylor.)

Radium.—The amount of radium in circulation has much increased of late, and much of this radium now comes to Teddington for the tests, which have to be carried to the highest accuracy obtainable with the aid of three methods, which we have described on former occasions—namely, the direct ionisation method, the Rutherford-Chadwick method, and the Curie piezo-electric method. The number of tubes tested was 124, against 88 and 16 in the two previous years. The radium arrives generally in tubes of platinum or silver of different diameters and wall thickness, and these points, the material and size of the tube, as well as the distribution of the salt in it, have to be considered in the estimates, which are now based on metallic radium, not on some one of its salts. Radium-luminous compounds are examined in the dry or wet, that is, the radium salt is added dry or in solution; the latter method

is more accurate. There is also a demand for tests of radium ores.

X-Rays. Spectrometer, Metallography, Pastilles, Protective Materials.—Several additions have been made to the equipment of Elm Lodge, in which the division is now housed. The high-tension leads are suspended from the ceiling; they are now made of copper wire embedded in 1 in. of solid rubber, rather than of wide metal tubes, which are apt to give coronal discharges at bends. The X-ray spectrometer, which we described last year (ENGINEERING, August 5, 1921, page 211) is now so fitted that Bragg (crystal reflection) observations can be taken on the one side of the big lead box, while the Debije-Scherrer method (a pencil of powdered material, jerked by a small motor, and surrounded by the film bent to a half-circle) is worked through a slit on the other side. When the insulation of high-tension apparatus consists of ebonite rods or plates, a ring of sulphur is let into the surface; the sulphur has no mechanical strength, but it prevents the creeping of surface films of moisture. For crystal work, a 60,000-volt transformer is used.

Another large lead box, 6 ft. by 3 ft. by 3 ft., made as the other boxes in the Laboratory, and weighing ¾ ton, serves for metallographical work. Through sliding panels of lead (6 mm. thick) the rays can emerge from two sides and the top or the bottom; all the high-tension connections are within the box as in the other cases. Current is drawn either from a transformer (10 kw., 120,000 volts) of Messrs. Watson, or from an induction coil (200,000 volts), made by Messrs. Cox; the two sources are joined to the same leads. All the coils are wrapped with oiled silk, to keep the Thames Valley moisture off the apparatus.

In the standardisation of the barium-platino cyanide pastilles, use is made of another lead box and of filtered and unfiltered radiations. The product of the ionisation per minute (produced in methyl iodide or in ethyl chloride) as given by the electroscope, and of the time of dose (the time taken to change the colour of a pastille from one tint to another, green to brown) is found to be constant and independent of the current, the volts in primary, or frequency and interval between make and break. In comparing the tints, the two pastilles are placed 1 cm. apart, and the images are brought in juxtaposition for ready comparison by an Ambrecht prism. When comparing the protective value of lead glass, lead rubber, shields, &c., which vary much in themselves and with time, Dr. Kaye avails himself of boxes of sliding lead plates, in order to make up screens of different thicknesses of lead; thus, all the comparisons are conveniently referred to an equivalent thickness of lead. The X-ray box used has two holes, about 1 cm. apart; each beam enters an ionisation chamber, the one through the specimen, the other through the lead screens; the two chambers are joined to a common electroscope, so that the positive leak in the one chamber is balanced against the negative leak in the other. Dr. Kaye is a member of the X-ray and Radium Protection Committee, and the research work is done in the Laboratory.

Optics Division (Messrs. T. Smith, J. Guild, J. S. Anderson).—There is cordial co-operation between the Laboratory staff and the optical staff of the Admiralty Research Department, accommodated in the Optics Building. The work on sextants and theodolites has fallen off considerably owing to the stagnation of trade, and probably also to the indispensable raising of the scale of fees. Sextants for use on aircraft have to be tested on special lines, as the possible error of the cam motion for the bubble lens may be much less regular than the centring errors of rotating-arm instruments. The revised tests of the watertightness of gun-sighting telescopes are also much more severe than the old tests, though stuffing boxes and grease are largely relied upon as before.

Equipment. Workshop.—The telescopes and collimator of the new spectrometer by Messrs. Watts and Sons, are provided with fluorite triple-cemented objectives, designed in the Division; the difficulty of obtaining suitable dense flints has delayed the completion of the instrument. The Zeiss-Pulfrich refractometer is a loan from the Admiralty Research Department. The workshop now supplies many of the new instruments. A constant temperature room is being fitted up.

Research.—The portable polarisation photometer for measuring surface-brightness has proved very successful. In some binoculars the marginal brightness amounts to over 60 per cent. of the centre brightness, in others it goes down to 25 per cent. As regards the reflecting powers of mirrors of various materials, notably of stainless steels and of glass platinised by the Rheinberg process, a report has been presented to the Physics Research Board. The progress of the investigation of optical settings has been slower than was anticipated, because the observations are very fatiguing, but a report on the properties of diagonally-mounted cross-wires is in preparation. The errors introduced in measurements when the objective of the observing telescopes is subdivided in certain ways by the limiting apertures of the entering light beam are found to be serious; errors amounting to 30 seconds of arc may occur in telescopes used for goniometric and spectroscopic measurements, supposed to be accurate within 1 second. With respect to the utilisation of a liquid surface as the ultimate standard of optical flatness, it seems very doubtful whether a liquid can be regarded a soptically flat under feasible conditions.

Colorimeters. Angle Comparators.—Various apparatus for the specification of colour were demonstrated by Mr. Guild on the inspection day. They included a Nutting monochromatic colorimeter by Messrs. Hilger, a Lovibond tintometer of improved pattern, a Rawtree trichromatic colorimeter and a novel trichromatic colorimeter for standardisation, designed and constructed at the Laboratory. In this last noteworthy instrument, the primary colours are mixed by means of a rotating periscopic prism which passes rapidly in front of three stationary sectorial openings of variable angles, in which the red, green and blue filters are placed. These filters have been carefully selected to give highly-saturated yellows and blue-greens, while provision is also made for the addition of white light to desaturate any colour under test which is of greater saturation than the most saturated colour given by the primary.

Finding that few of the goniometers and auto-collimating telescopes in the country can be relied upon within 1 second of arc, and that interference fringe methods are too laborious for anything but standardisation work, Mr. Gould has further developed his substitution method, in which the minute difference between the angle under test and a standard of the same nominal value is measured.

Standards of 90, 60, 45 and 30 deg. are available, though not themselves perfect. Supposing we wish to measure a prism of 60 deg. The prism is placed on a table, radially to which a collimator and two telescopes T_1 and T_2 are arranged at angles of 120 deg., so that the collimator beam sends light to both the faces of the prism, and images are seen in the two telescopes; T_2 is provided with a micrometer eye-piece. When T_2 is adjusted, the prism is replaced by the standard; T_2 will then generally require a further adjustment for the slight angular difference to be measured. To avoid the mechanical imperfection of the micrometer screw, a wedge device has recently been adopted in the improved instrument. This wedge consists of a positive and a negative lens, each of 8 m. focal length, mounted in a frame so as to leave the one lens movable; the wedge is placed between the telescope objective and its focal plane, close to the latter. The instrument is complicated; the essential parts in alignment are the following: the pointolite lamp, a lens, a cell to absorb heat rays, a slit with two transverse and one vertical fibre, the variable-prism wedge (moving across the axis) with scale and vernier, the collimator (an astronomical telescope), the prism on its table, and the observing telescope; the wedge is operated from the eye end of the bench. Near this end are also two plane stationary mirrors, which should be perfect and are so obscured by screens that either the left or the right prism face can be observed. There are, further, an auxiliary eye-piece and other parts. A displacement of the variable lens through 1 mm. would correspond to an angular difference of 0·5 second, and readings can be taken to 0·1 mm. or 1-20th of a second.

Measuring the Internal Diameters of Transparent Tubes.—In conjunction with Dr. Guy Barr, Dr. J. S. Anderson has developed two new methods of determining the internal diameter of a glass or quartz tube. The first method consists in immersing the tube under test in a suitable liquid and varying the wave-length of the illuminating beam until the glass and the liquid have the same refractive index; the system being thus homogeneous, the diameter can be measured directly. The index of the glass need not accurately be known. The method is thus a development of Dr. Anderson's method of determining the index of a piece of glass of irregular form by immersing it in a liquid of high index which is then diluted to make the indices equal for some wave-length λ. To effect this dilution may be a laborious undertaking, and the new method only adjusts the index roughly for some λ in the visible spectrum and then varies the λ for accurate equality. The light from a lamp passes through a collimator, a prism, and a traversing slit which selects some monochromatic beam, then falling on the rectangular glass cell, filled with the liquid, in which the tube under test, say a thermometer tube, is immersed. In front of the cell is a microscope provided with an eye-piece scale; either the cell or the microscope can traverse on a stage.

Supposing we can look directly through the cell at a lamp filament, either through the glass tube in the liquid or through the liquid underneath it. The glass of the tube would act like a prism, and when the indices of the glass and of the liquid are the same, the two images of the filament (seen through the glass and the liquid, and through the liquid alone) will coincide. When the indices differ, we shall see two images, or rather, two spectra, on the right and on the left of the filament. The rough adjustment of the apparatus is effected on this principle. The further adjustment is obtained in another way. Assume that we have approximately adjusted for light green. When the observing microscope is then focussed a little in front of the outside edge of the tube, a dark band will appear near the edge as the light is shifted over to the yellow-red, while fringes will be seen with blue light; when we focus a little behind the edge, the band will appear in the blue. This band will widen as we further deviate from the correct λ. By focussing the microscope as described and by watching the band, the correct λ is found. There are other ways of doing this. When it has been done, the hollow in the tube will appear dark, whether the tube contain air or mercury, and measurements can be made; the glass surface may be smooth or ground—that does not matter with immersion methods. There are a great variety of suitable inexpensive liquids available, ranging in index from methyl acetate 1·448 to methylene iodide 1·740. The parts of the glass cell, if built up, are best held together by framework without any cement, which the organic liquids might attack unless protected by bichromate jelly.

The second simple method relies on X-ray photography. The tube is mounted immediately in front of the photographic plate, at considerable distance (2 m.) from the X-ray bulb. The tube is best filled with mercury, but it may be empty. A metal rod or sphere, of known diameter, may be placed coaxially with the tube, so that the observer can correct for the influence of divergent rays. This method gives permanent records of several tubes on the same plate, but measurements (on the negative) are not reliable within less than 0·005 mm.

(To be continued.)

RECORD SHIPMENTS OF SWEDISH IRON ORE.—The port of Narvik is stated never to have been, as at present, so full of steamers waiting for iron ore, although it should be added that the facilities and equipment for loading at that port leave nothing to be desired. The exports from Narvik during the first six months of the present year amounted to 2,258,000 tons, against 1,798,000 tons for the corresponding period of 1921, and 1,688,000 tons for the corresponding period of 1913, which was the record figure until then. The Lapland ore can easily compete with others on the world's markets, owing to its comparatively low cost of production and its high percentage of iron. The total exports of iron-ore from Sweden during the first half of the present year by the Grängesberg-Oxelösund concern, which literally controls the whole of Sweden's export of iron ore, amounted to about 2,600,000 tons, against 2,018,000 tons for the corresponding period of 1921. This total includes shipments from Narvik, Luled and Oxelösund, Narvik being by far the most important.

TURBO-COMPRESSORS FOR HIGH-SPEED AVIATION.

*The Use of the Turbo-Compressor for attaining the Greatest Possible Speeds in Aviation. Specific Pressures and Weights of Air under Normal Atmospheric Conditions.**

By Professeur A. RATEAU, of Paris, Member.

(*Concluded from page* 94.)

SINCE the armistice the investigations and applications have been continued steadily. Various details required perfecting, particularly the exhaust pipes which, at the commencement, were not of sufficient strength to avoid leakage; the petrol pumps also had not been designed to supply petrol at a pressure exceeding one-half atmosphere. Now, however, the engineers and pilots of the Technical Section, Mr. J. Weiss in particular—who worked for a long while in 1919 on a military Breguet aeroplane—whose assistance has thrown much light on the subject, and more recently the devoted pilots of Le Bourget Aerodrome, who kept in regular use a squadron of Breguet aeroplanes, have succeeded in freeing the installations on board the aeroplane from all those inconveniences that had made themselves apparent in practical working. So far, as the main feature is concerned, that is the turbo-compressor itself, no modification was required.

In Fig. 5 is shown the rotor of a turbo-compressor designed for supercharging motors of 300 h.p.; this rotor has a total weight of 3 kg. The turbine wheel, 18 cm. in diameter, is made of tungsten steel, the tool steel discovered by F. W. Taylor; notwithstanding its small dimensions this turbine develops nearly 50 h.p. with the exhaust gas of a 300 h.p. motor. The compressor wheel or fan, 24·2 cm. in diameter machined from the solid, is made of nickel steel, as also is the shaft. The blades, nine in number, are exactly radial and machined to the calculated form of a solid of equal strength so that they may undergo no deformation by centrifugal force. The shaft, which is 33 cm. long between bearings, appears relatively strong, yet its first critical speed is as low as 8,000 r.p.m., and its second is at 27,000. The machine runs normally at 25,000 r.p.m. to 30,000 r.p.m. hence in the zone of this critical speed.

In Fig. 6 is shown a photograph of the turbo-compressor, and in Fig. 7 the general arrangement with a section of the turbo-compressor. The casing of the compressor is in aluminium, and that of the turbine in steel plate. The whole machine weighs only 23 kg.

A radiator is shown for cooling the compressed air from the compressor before its arrival at the carburettor. It is well known that air becomes heated when compressed; if, for example, air is drawn in at 250 deg. absolute C., the heating for a ratio of compression of 2, and an efficiency of 55 per cent., is 90 deg. C.; the air therefore leaves the compressor at a temperature of 340 deg. absolute C., that is 67 deg. C. It must be cooled if power is not to be lost in the motor. This is very important, not only from this point of view, but also for avoiding any kind of unsteadiness of running which may be caused by this heating.

The whole arrangement, including all accessories, weighs about 80 kg., under the actual conditions of adapting it to old aeroplanes. It would be possible to reduce this weight very considerably if it were decided to design the motors specially with a view to their use in combination with the turbo-compressor.

The advantage is shown clearly by the figure given above. With an added weight of 80 kg. the power is doubled at high altitudes for a motor giving 300 h.p. at ground level; on the other hand an ordinary 600-h.p. motor would weigh an extra 350 kg. at least. It must be noted also that the 300-h.p. motor, continuing to run under the same conditions as exist at ground level, maintains its efficiency, whereas, on account of passive resistance (engine friction, &c.) the 600-h.p. motor, without the turbo-compressor, shows appreciable falling-off in power at high altitudes.

What are the results that may be expected from the new arrangement? Taking into consideration only those appliances that have been actually tested, and give double the induction pressure (and there would be no difficulty, if required, in making these appliances capable of compressing the air to a much greater ratio), the formulæ which the author has established, and which are given in the appendix, show that, for equal weight of aeroplane, there is an increase of about 4,000 m. in the height of ceiling. And actually on a Breguet aeroplane having its ceiling at about 6,000 m., Lieutenant J. Weiss, after a turbo-compressor had been fitted, flew, in July, 1919, with his mechanic, to a height of over 9,000 m., and he was still far from the new ceiling. This is the record for height with a passenger. The absolute record for height is held by the American, Lieutenant J. A. MacReady, who flew, on September 28, 1921, from the Cookfield Aerodrome, near Dayton, Ohio, to a height of rather over 10,500 m. on an aeroplane fitted with a 450-h.p. motor and a turbo-compressor modelled on the author's design, so far as concerns the essential features.*

With regard to speed, there is a loss at ground level, because it is necessary to change the airscrew and to substitute for it one of larger diameter in order to be able to maintain the speed of the motor at high altitudes within the permissible range of speed. But above 2,000 m. the turbo-compressor rapidly makes up for this. A few figures will serve to explain. The Breguet aeroplanes in question, fitted with 300-h.p. motors, without turbo-compressors, have a normal speed at ground level of 180 km. per hour; near the ceiling this speed falls to 145 km. per hour. With the addition of the turbo-compressor a speed is obtained, at the former ceiling height of 6,000 m., which from many measurements has been found to be from 215 km. to 220 km. per hour. At this speed many flights have been made with these aeroplanes from Paris to Lyons, to Tours, to Nancy, to Metz, &c.

The diagram shown in Fig. 8 gives a clear idea of the comparison of the speeds at constant altitude and in climbing for the particular case under consideration. The broken lines relate to the normal aeroplane and the full lines to the aeroplane fitted with the turbo-compressor.

The reduction of speed near the ground is due to the airscrew having a greater pitch than that for the normal aeroplane and that the motor consequently runs at an appreciably slower speed. This disadvantage could be avoided by the use of an airscrew of variable pitch so as to enable the motor to be run under all conditions at its proper speed. But it will be seen from the curves that the advantage to be obtained from this is not important.

On the other hand, it would not be possible to avoid the use of an airscrew of this type if the turbo-compressor group were arranged for running so as to give the ground pressure at an altitude of 10 km. to 12 km. instead of at 5 km. or 6 km. With an airscrew of constant pitch too much speed would be lost near the ground level and taking off would be difficult, if not impossible.

There is no difficulty in designing turbo-compressors for these great altitudes, for which it would be necessary

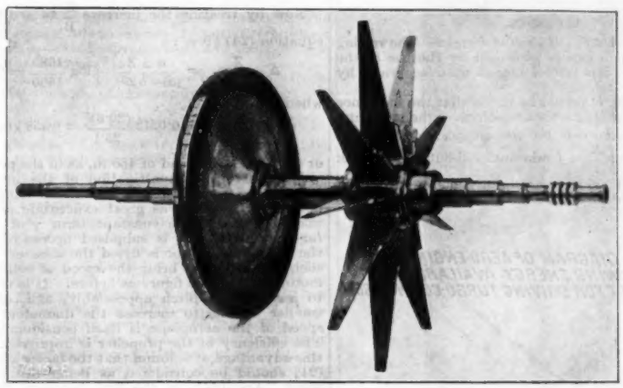


FIG. 5. ROTOR OF TURBO-COMPRESSOR FOR SUPERCHARGING 300-H.P. MOTOR.

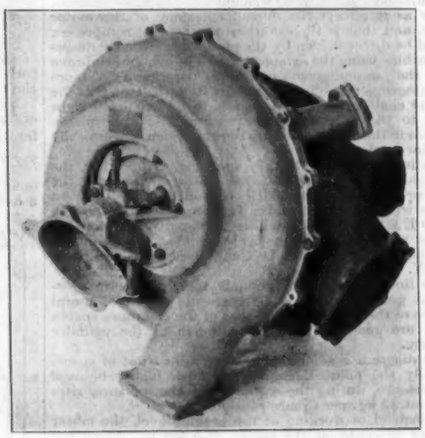


FIG. 6. TURBO-COMPRESSOR FOR SUPERCHARGING AERO-ENGINE.

Fig. 7. ARRANGEMENT OF TURBO-COMPRESSOR SUPERCHARGER (RATEAU)

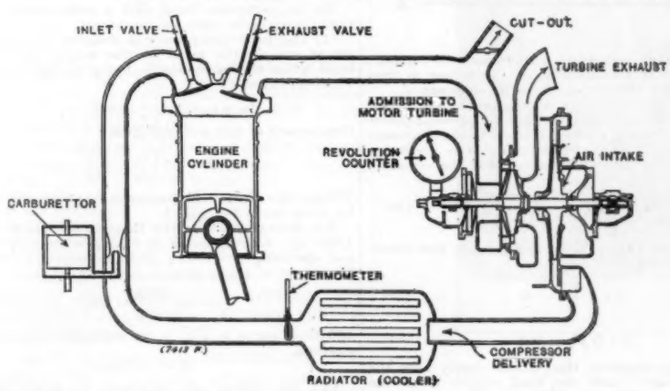
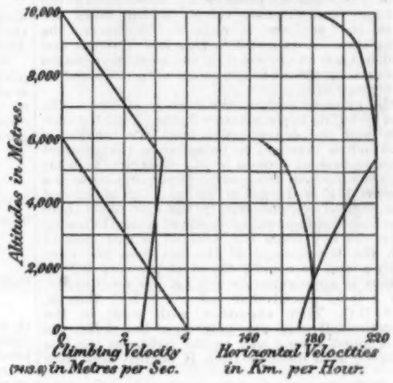


Fig. 8. COMPARISON OF CLIMBING & FLYING SPEEDS.



* Paper read at the Paris meeting of the Institution of Mechanical Engineers, June 15, 1922.

* This notwithstanding, the engineers of the General Electric Company have endeavoured to spread the belief that they had invented the apparatus themselves. Proof exists that their designs were only commenced after the French trials at Galibier in August 1917, and that they were in possession of the information contained in the first working drawings and of the results of all the trials made at the Villacoublay Aerodrome.

to raise the pressure four, or even five-fold, either by means of a multicellular compressor with two or three wheels, or better still by arranging in series two turbines similar to those described.

It has sometimes been stated that the distributor of the turbine, having convergent nozzles is not adapted for a drop of pressure of more than one-half the initial pressure, and that, for this reason, the apparatus has not the same efficiency at high altitudes, above 5 km. or 6 km. This is an error due entirely to a want of appreciation of the properties of turbines working in an elastic fluid.

In the first place it would be very simple to make distributors with convergo-divergent nozzles, as is done for steam turbines when necessary. But then it must be borne in mind that nozzles which are only convergent give good efficiency when the pressure on entering is much more than double the pressure of delivery; the efficiency even increases as the expansion ratio increases, up to a certain limit, because the turbine then works partly by reaction and the losses in the nozzles and those due to shock on entering the rotating wheel are lower. It has appeared to the author advisable to deal somewhat fully with this point, which is so frequently misunderstood.

One other point, which is very important, merits examination; it might be thought to be of small interest, so far as it affects the overall efficiency of the motor group, and that is the question whether the compressor should be direct-driven by the motor or driven by means of a turbine using the exhaust gas. The author can prove that the second combination is considerably more advantageous; briefly, this results from the fact that the turbine enables the exhaust gases to be expanded right down to the pressure of the surrounding atmosphere, whereas in the motor cylinders the expansion is necessarily very incomplete.

Let it be assumed that, in one case or the other, the turbo-compressor supplies the motor at exactly the same pressure as at ground level, and that the diagram of the working of the motor is represented by the line G C D E F C G, Fig. 9, which is the diagram for the engine working as a four-cycle engine. The volumes are plotted as abscissæ on O X and pressures as ordinates on O Y.

The line L G C J corresponds to atmospheric pressure at ground level. A B represents the total useful volume of the cylinders, O A that of the clearance spaces which are generally about one-fourth of the cylinder capacity.

The diagram is somewhat distorted for want of space. Actually the point E should be much higher because the pressure, during the explosion of the mixture, rises to about 25 kg. per square centimetre.

If, instead of working at the ground-level, the motor ran, for example, at the height of 5,400 m., where the atmospheric pressure is reduced to one-half, then in the case in which it exhausts direct to the atmosphere, the diagram would be increased by the rectangle G C I H of one-half the height. But the useful work on the shaft is appreciably smaller than the area of this rectangle, firstly, on account of the passive resistance, and secondly, because of the losses of pressure by wire-drawing the gases through the exhaust valves, which losses are greater as the pressure is reduced. Moreover, the multiplying-gear causes a still further loss of power and consequently only 85 per cent. of the work represented by the area L of the rectangle is actually delivered to the turbo-compressor.

With the exhaust turbine the case is altered. The gas begins by falling to the pressure in the piping between the motor and the delivery-pipe from the turbine, a pressure which is assumed to be equal to the pressure of one atmosphere at ground level. Contrary to what is sometimes supposed, the energy corresponding to the total pressure B F of the gas in the cylinders is not and cannot be utilised completely. In the first place there is rapid exhaust without performance of work, following a portion of the hyperbola F J, because in this class of expansion the temperature of the gas does not vary appreciably; and as usually the final pressure B F in the cylinders is approximately 4·5 kg. per centimetre², the point J is so placed that L J = 4·5 L C, that is, G J = 5·4 G C. Then expansion with work in the turbine occurs following the polytropic line J K; the point K is found a long way to the right, on the line H I produced, at a distance from H slightly less than 2 G J.

The theoretical work done in the turbine is represented by the trapezoid, the area of which is about equal to seven times that of the rectangle G C I H. But the useful work transmitted to the compressor-shaft is less. If the efficiency of the turbine is only 50 per cent., and, actually it is rather more, this is nevertheless 3·5 times G C I H, whereas in the first case considered it was about 0·85.

It will be seen that this solution gives available power for the compressor while leaving the utilisable power of the motor unchanged, and it gives at least four times as much power as would be obtained by a direct drive from the motor itself through multiplying gears. It has, therefore, a very great advantage.

Conclusions.—To sum up, it has been shown that speeds of 300 km. per hour are already attainable with commercial long-distance aeroplanes, and about 400 km. per hour with war or sport machines, flying ordinarily at an altitude of 5 km. or 6 km.

In order to obtain still higher speeds, greater progress must be made as follows:—

The construction must be made still lighter.

The form of the wings and of the dead-wood must be improved as to reduce the fineness to less than 0·10; this is obviously possible, because the fineness of the wings alone can be reduced to less than 0·045; the experimental laboratories can give the greatest assistance in these investigations.

The production of a thoroughly reliable variable pitch airscrew.

The construction of an air-tight chamber, in the first place, for the passengers, and secondly, for the crew, which must combine sufficiently lightness with perfect safety.

In addition to these, improvement is necessary in the motors, particularly with regard to the length of time they will run and their ability to sustain uniform running speed.

When these improvements have been effected, and when the aerial ways have been organised, it will be possible to travel round the world at speeds of over 400 km. per hour, and by stages of 1,500 km. to 3,000 km. it will be possible to fly from Paris to Tokio, for example, in three days with eight stages; Paris to Buenos Aires in two days with five stages, of which one—the Atlantic crossing from Dakar to Pernambuco, 3,300 km. is unfortunately rather long. M. Breguet has already led us to hope for a fairly early realisation of these schemes, and this statement has the weight which his word usually carries.

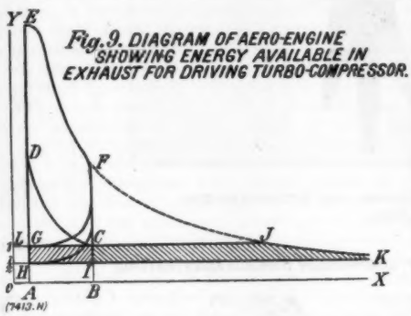
Progress is being made rapidly. In a few years the stratosphere will doubtless have become the great international route of travel.

APPENDIX.

Note on the Calculation of Ceiling Height.—The raising of the ceiling, which can be obtained by the use of the turbo-compressor, can be calculated with accuracy by the following method.

In the first place, it should be noted that the incidence of flight α_p at the ceiling is that which gives the minimum for the total resistance R for the aeroplane, that is to say that also gives $\frac{X}{Y} = f$ minimum, about 4 deg. with modern types of machines, or slightly more, say about 5 deg., because the slip of the airscrew, which increases with the incidence, raises the maximum still further; the slip outflow of the airscrew at the ceiling is then determined in this manner as also is its efficiency η.

Fig. 9. DIAGRAM OF AERO-ENGINE SHOWING ENERGY AVAILABLE IN EXHAUST FOR DRIVING TURBO-COMPRESSOR.



(7413. H)

Where n is the number of revolutions of the motor per second and Q its torque, the useful propelling-power is expressed by $2\pi n Q \eta$ which is equal to the resistance of the aeroplane $X \rho v^2$, and replacing v by its value obtained from the second equation (13) the equation gives:—

$$2\pi n Q \eta = \frac{X}{Y^{\frac{2}{3}}} \cdot \frac{W^{\frac{2}{3}}}{\rho^{\frac{1}{3}}} \quad . \quad . \quad (19)$$

For a given aeroplane, X, Y, and η being also determined at the ceiling, let:

$$2\pi\eta \frac{Y^{\frac{2}{3}}}{X} = \psi, \quad . \quad . \quad . \quad (20)$$

from which:

$$\psi n Q \rho^{\frac{1}{3}} = W^{\frac{2}{3}} \quad . \quad . \quad . \quad (21)$$

It is this simple equation that shows clearly how the ceiling-height varies when the total weight W or the torque Q of the engine are varied.

Investigating in the first place the influence of variation of weight. If it is supposed that, for relatively small variations the torque Q of the motor is proportional to the specific weight of the air, let:

$$Q = A\rho.$$

then (21) becomes:

$$\psi n A \rho^{\frac{2}{3}} = W^{\frac{2}{3}} \quad . \quad . \quad (22)$$

Moreover (19), under the same assumption, gives:

$$2\pi A n \eta = X v^3 \quad . \quad . \quad (23)$$

As, at the ceiling, n is proportional to v (because the slip of airscrew is known), it will be seen from this equation that *the speed* V *at the ceiling is independent of the total weight* W *of the aeroplane as also is n, the speed of rotation of the motor*; and (22) then shows that ρ is directly proportional to W; hence, if the ceilings Z_1 and Z_2 are compared, that correspond to two different weights W_1 and W_2 of the same aeroplane:

$$\frac{\rho_2}{\rho_1} = \frac{W_2}{W_1},$$

and, taking logarithms and using equation (9),

$$\frac{Z_1}{B_1} - \frac{Z_2}{B_2} = \log \frac{W_2}{W_1} \quad . \quad . \quad (24)$$

In particular, if the coefficient B can be considered as constant, as is the case in the stratosphere, or of altitudes comprised between 3 km. and 6 km.:

$$Z_1 - Z_2 = B \log \frac{W_2}{W_1} \quad . \quad . \quad (24A)$$

The following is an example of a calculation which will serve later. Taking the case of the Breguet aeroplane, weighing in the first instance 1,600 kg. in running order, to which the turbo-compressor has been added, which, with its accessories, increases the total weight by 80 kg. At the former ceiling of 6 km. the coefficient B, according to curve 4 of Fig. 1 is appreciably constant and equal to 21·7.

Then from (24A):

$$Z_1 - Z_2 = 21{\cdot}7 \log \frac{1680}{1600} = 0{\cdot}460.$$

Thus this extra weight of 80 kg. lowers the original ceiling by 460 m.

On the other hand, with the turbo-compressor, the new ceiling is raised to about 10 km., as will be seen; at this altitude the coefficient B varies rapidly. Taking the tangent to the curve 4 to the abscissa Z = 10, this portion of the curve can be replaced by the straight line $B = 25{\cdot}1 - 0{\cdot}45\,Z = a - bZ$.

Now by treating the increase $\frac{Z}{B}$ as a differential the equation (24) gives:

$$\Delta \frac{Z}{a - bZ} = \frac{a\,\Delta Z}{(a - bZ^2)} = \log \frac{1680}{1600} = 0{\cdot}0212;$$

whence

$$\Delta Z = 0{\cdot}0212 \frac{(20{\cdot}6)^2}{25{\cdot}1} = 0{\cdot}358 \text{ km.}$$

or only 358 m. instead of 460 m. as in the previous case.

Passing to the investigation of the increase of the torque due to the use of the turbo-compressor, it is necessary to obtain as great exactitude as possible, to take account of the constant term γ of formula (18) for the torque. It is supposed necessarily that when the turbo-compressor is fitted the airscrew is altered in such manner as to bring the speed of rotation n of the motor to the same figure as before. It is then necessary to increase the pitch appreciably, and, although to a smaller extent, to increase the diameter, because the speed of the aeroplane is itself considerably increased. The efficiency of the propeller is improved. Neglecting this advantage, it is found that the factor ψn of equation (21) should be considered as being the same in both cases. Assuming, in the first instance, that the total weight W has not been altered; the correction corresponding to the added weight will be made subsequently.

For the aeroplane without the turbo-compressor, according to (21):

$$\psi n A (\rho_1 - \gamma) \rho_1^{\frac{1}{3}} = W^{\frac{2}{3}} \quad . \quad . \quad (25)$$

For an aeroplane fitted with a turbo-compressor two main hypotheses must be considered.

(1) The turbo-compressor is designed so as to deliver air of exactly the same specific weight as at ground-level when the aeroplane is flying at the new ceiling. Then (21) gives:

$$\psi n A (\rho_0 - \gamma) \rho_2^{\frac{1}{3}} = W^{\frac{2}{3}} \quad . \quad . \quad . \quad (26)$$

Comparison of (25) and (26) gives:

$$\rho_2 = \rho_1 \left[\frac{\rho_1 - \gamma}{\rho_0 - \gamma}\right]^2 \quad . \quad . \quad . \quad (27)$$

Whence the altitude Z_2 corresponding to it can be found by using curve 4 of Fig. 1.

For example, taking the Breguet aeroplane weighing 1,600 kg., with a ceiling at 6 km., whence $\rho_1 = 0{\cdot}661$, and assuming $\gamma = 0{\cdot}12$; and, moreover, $\rho = 1{\cdot}248$. The equation above gives $\rho_2 = 0{\cdot}152$, whence

$$\frac{Z}{B} = \log \frac{1{\cdot}243}{0{\cdot}152} = 0{\cdot}914,$$

and from curve 4, Fig. 1, by successive close approximations,

$$Z = 16{\cdot}4 \text{ km.}$$

The new ceiling will, therefore, be rather less than three times the height of the first.

At lower altitudes the contrary will occur; the new ceiling will be at a little more than three times the old height.

(2) The turbo-compressor is calculated on such basis as to increase the specific weight of the air always in the same ratio m from the altitude at which it runs at its maximum speed.

Then equation (25) becomes:

$$\psi n A (m\rho_2 - \gamma) \rho_2^{\frac{1}{3}} = W^{\frac{2}{3}} \quad . \quad . \quad (28)$$

Whence, comparing (25) and (28),

$$(m\rho_2 - \gamma)^2 \rho_2 = (\rho_1 - \gamma)^2 \rho_1 \quad . \quad . \quad (29)$$

Now suppose $m = 2$, which is approximately obtained from the existing turbo-compressors in work, provided that the air is cooled sufficiently by the radiators, $\gamma = 0{\cdot}12$ and $\rho_1 = 0{\cdot}661$, which corresponds to $Z = 6$ km., as above; the equation of the third degree above becomes

$$(\rho_2 - 0{\cdot}06)^2 \rho_2 = 0{\cdot}0484,$$

which can be solved easily with the help of a slide-rule. It is thus found that:

$$\rho_2 = 0{\cdot}4055,$$

to which corresponds, according to curve 4, Fig. 1,

$$Z = 10{\cdot}045 \text{ km.}$$

The ceiling, for equal total weight of aeroplane, will therefore be raised by 4,045 m., and, taking account of the

drop, already calculated, of 358 m., due to the added weight of 80 kg., it is actually 4,045 − 358, or, in round figures, 3,690 m.

If the constant were treated as negligible in the expression for the torque, the formulæ would be simplified, and (29) would become:

$$\rho_2 = \frac{\rho_1}{m^{\frac{3}{4}}} \quad . \quad . \quad . \quad (30)$$

Whence, taking logarithms and using equation (9):

$$\frac{Z_2}{B_2} - \frac{Z_1}{B_1} = \frac{3}{4} \log m \quad . \quad . \quad (31)$$

It would thus have been found that for the preceding numerical example $\rho_2 = 0{\cdot}4164$ and $Z_2 = 9{\cdot}853$ km.; the error would have been 192 m. less, which is appreciable. It should also be noted, that, at this altitude, the effect of the passive resistances of the motor compensate in greater part for the effect of the added weight of the supercharging apparatus.

The coefficient B varies with the altitude, and it diminishes continually with increase of altitude; but between 3 km. and 6·5 km. it is sensibly constant. Then, if Z_2 and Z_1 remain within these limits, the formula (31) becomes:

$$Z_2 - Z_1 = \frac{3}{4} B \log m, \text{ with } B = 21{\cdot}8 \quad (31A)$$

And it will be seen that, under these conditions, the raising of the ceiling, due to the use of a turbo-compressor which increases m-fold the specific weight of the induction air of the motor, is constant.

But in more general terms this is not exactly true. Since B_2 is less than B_1, it necessarily follows from (31) that:

$$Z_2 - Z_1 < \frac{3}{4} B \log m \quad . \quad . \quad (32)$$

where B is given a value equal to, or greater than, B_2, for example B_1, which corresponds to the altitude Z_1 of the comparison; and as B is a diminishing quantity, the same applies to the raising of the ceiling. If, for example, the aeroplane previously considered had had a ceiling of 10 km. instead of 6 km., it would have been found, by making the exact calculations according to the complete formula (29), that the raising of the ceiling was 3,400 m. instead of 4,045, for equal weights of aeroplanes, and a reduction of 310 m. instead of 358 m. for the same proportional added weight, that is to say, a net increase of elevation of 3,090 m. instead of 3,690 m.

For the sake of completeness, the increased heights of ceiling calculated by formula (29) for an aeroplane having a ceiling in the first instance, of 2,000 m., of 4,000 m., &c., are shown in the table below (column 1) for equal weights of aeroplane after the addition of a turbo-compressor increasing the specific weight of the air to double (column 2), or four-fold (column 3), in the normal atmosphere.

Z_1	$Z_2 - Z_1$	
	$m = 2$	$m = 4$
m.	m.	m.
2,000	4,480	8,325
4,000	4,370	7,870
6,000	4,045	7,280
8,000	3,685	6,825
10,000	3,400	6,520

These values of $Z_2 - Z_1$ are, in accordance with equation (32), much less than $\frac{3}{4} B_2 \log m$, except the two first of each column; this is due to the influence of the passive resistances of the motor, which are omitted in the simplified equations (31) and (32).

Table of Symbols Differing in French and English Notation.

French.	English.
P Poids.	W Weight.
Π Puissance.	P Power.
ϖ Poids spécifique.	ρ Density.
ρ Rendement.	η Efficiency.
Γ Couple moteur.	Q Torque.
Log. nep, Log Néperien.	Log_e, Napierian log.

INFLUENCE OF DISSOLVED OXIDES ON CARBURISING AND HARDENING QUALITIES OF STEEL.*

By E. W. Ehn (Canton, Ohio, U.S.A.)

Introduction.—It is generally assumed that steels of similar chemical composition should respond similarly to case-hardening operations, and that if these be properly conducted, satisfactory results should be obtained. The object of this paper is to show that this is far from true, and that the presence in the steel of non-metallic impurities in solid solutions, presumably oxides, due to improper deoxidation of the steel when made, affects permanently the carburising and hardening qualities of the steel. This paper will deal mainly with straight low-carbon steel, S.A.E. 1,020, but it will also be shown that the same factors govern the hardening of high-carbon steels, and that valuable information can be obtained by submitting steel of this kind to carburising tests.

Many papers have been written and much work has been done on determining the effects of various alloying elements on the rate of penetration, structure, &c., but very little, if anything, has been published in regard to the varying results obtained with steel of the same analysis, and ascertaining the requirements for steel for carburising purposes. This paper will show that certain steels, although fulfilling specifications as regards analysis and physical properties, are entirely unsuitable for carburising. This is, moreover, not merely an interesting theoretical experience, but a commercial fact of the greatest importance, as this condition in the steel is far more common than is usually suspected.

* Abstract of a paper read before the Iron and Steel Institute, on Friday, May 5, 1922.

In the plant with which the writer is connected hundreds of tons of steel have been diverted to other purposes than carburising, and thousands of dollars of half-finished work rejected owing to improper quality of the steel. As a rough estimate, about 25 per cent. of all steel bought from outside sources has been found unsuitable for carburising, in spite of the fact that such steel was bought from some of the most reputable steel-makers in the country and in accordance with commonly used specifications.

In hardening carburised parts mysterious failures to obtain a uniformly hard product are often reported, and owing to this fact there has arisen a certain lack of confidence in case-hardened parts. This is very much to be regretted, as it has been definitely proved by recent research work that for many machine parts subject to fatigue stress, properly case-hardened work is far superior to any parts made of hardened high-carbon steel with or without alloying elements.* On investigating a number of failures of this kind from different plants, the reason for the failure in hardening has almost invariably been found to be caused by improperly deoxidised steel. It will be shown that the degree of deoxidation of the steel affects directly all the important factors in carburising, namely, depth of case, maximum carbon content, structure of case and core, and, last but not least, the way the carburised work responds to the final hardening operation.

This paper will, where not otherwise stated, deal with steel of the following composition:—

	Per Cent.
Carbon	0·15 to 0·20
Manganese	0·35 to 0·65
Phosphorus, below	0·040
Sulphur	0·040
Silicon	0·005 to 0·010

* See, for instance, J. Miller, Transactions of the American Society for Steel Treating, March, 1921.

The plant with which the author is connected is devoted to the manufacture of tapered roller bearings. In the hardening department of this plant it would occasionally happen, in spite of extreme care, that a large amount of carburised work failed to harden properly and had to be rejected, owing to the occurrence of soft troostitic spots. These failures were at first attributed to faulty carburising or hardening practice, but after considerable research work it was definitely proved that the cause was some inherent property in the steel itself. The failures in the hardening were always traced to special lots, while other lots that had simultaneously undergone the same processes gave no trouble whatever. Different carburising compounds and different methods of quenching were tried, but failed to improve the results, and by gradually working back through the different stages of conversion of the steel it was finally proved that the carburising and hardening qualities were inherent in the ingot itself, and unchanged in any way by different operations in the course of manufacture. It was also found that this feature of soft spots in the steel was always combined with a special fine-grained structure in the carburised part.

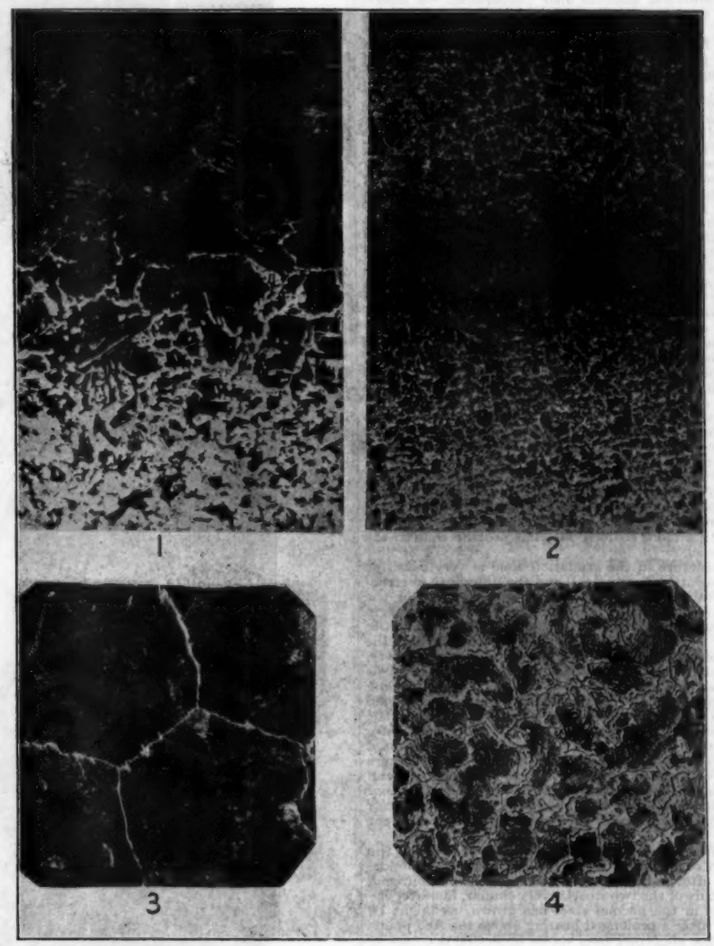


FIG. 1. CASE OF NORMAL STEEL. × 50. WILL GIVE A MARTENSITIC CASE IN HARDENING. FIG. 2. CASE OF ABNORMAL STEEL. × 50. WILL GIVE SOFT TROOSTITIC SPOTS IN HARDENING. FIG. 3. HYPEREUTECTOID ZONE OF NORMAL STEEL. × 200. FIG. 4. HYPEREUTECTOID ZONE OF ABNORMAL STEEL. × 200.

SPECIMENS ETCHED WITH 5 PER CENT. PICRIC ACID.

Steels which on hardening in water acquire a uniformly hard martensitic case will, in what follows, be referred to as normal, whereas steel giving soft spots in the hardening will be called abnormal.

PART I.—MICROSTRUCTURES AND PROPERTIES OF NORMAL AND ABNORMAL STEEL OBTAINED UNDER OPERATING CONDITIONS.

The carburising referred to in this part has been done in hydrocarbonated bone-black at 900 deg. to 925 deg. C., followed by the cooling of the pots in the air. As the pots used are of a comparatively large size and the bone-black is not a good conductor of heat, cooling is comparatively slow, and varies to a certain extent in different parts of the pot. Measurements made in the centre of the pots show the following values: 925 deg. to 800 deg. C. in 35 minutes, 800 deg. to 700 deg. C. in 25

minutes, and 700 deg. to 600 deg. C. in 35 minutes. This rate can, however, be varied within comparatively wide limits without great changes in structure. The use of a higher carburising temperature gives different structures, but this change is not obtained until a considerably higher temperature than 925 deg. C. is employed. The influence of varying temperature and rate of cooling will be dealt with in a later part.

In order to develop clearly the difference in microstructure of normal and abnormal steel, it is desirable that the carbon content of the hypereutectoid zone be 1·05 per cent. or more. With the carburising done as outlined above, a case of eutectoid or slightly hypereutectoid composition is obtained, at least for cases of less than 0·040 in. depth. Most of the photo-micrographs are therefore taken from samples with greater depth of case, or in a few cases from specimens specially prepared to conform with this condition.

Microstructures obtained after Carburising.—A microscopical examination of carburised work reveals a large number of different types of microstructures fairly uniform for parts made of steel from the same lot, but varying greatly with different lots. The necessity of restricting the number of photomicrographs makes it, however, possible to show only a few of the most representative types. Figs. 1 and 2 show typical structures of normal and abnormal steel after carburising. The first steel will harden without difficulty, whereas the other will give soft, troostitic spots in hardening. The typical structures in the different parts of the case will be better understood from separate photographs at a higher magnification, taken from specimens other than those used for Figs. 1 and 2.

Figs. 3 and 4 show the extreme types of normal and abnormal steel. In the normal steel the hypereutectoid zone (Fig. 3) consists of pearlite and free cementite sharply defined at the grain boundaries or lying as needles throughout the mass of the crystals. The grains are generally large and sharp-cornered in outline. The hypereutectoid zone of very abnormal steel (Fig. 4) consists of pearlite, cementite, and free ferrite. The cementite lies as small curly fragments in a mass of ferrite formed by the divorce, more or less complete, of the pearlite. The outlines of the crystals are not well defined, do not follow straight lines, and the size is small compared with the normal steel. In order to develop this structure clearly it is necessary that excess cementite be present, the more the better, and the most pronounced types of this structure are therefore obtained in the corners of the specimens, where sometimes an almost complete divorce of the pearlite can be obtained.

The difference is, at least in commercial steels, not very pronounced, but some cases have been observed where the abnormal steel shows a somewhat "fiery" appearance, with a more coarsely lamellar pearlite than in the normal steel.

The structure in the gradation zone is very sensitive to any variation in the steel, and the difference in structures obtained is even more pronounced than in the hypereutectoid zone. This is especially important in an eutectoid case, where the absence of excess cementite prevents the formation of the typical structure of the hypereutectoid zone, although it must be noted, however, that the structure of the gradation zone is more dependent on the carburising temperature and the rate of cooling than that of the hypereutectoid zone. The normal structure in the gradation zone (Fig. 5) is as triangular, or at least sharp-cornered areas of pearlite with sides not less than $\frac{1}{2}$ in. at 100 magnifications and separated by clearly-defined ferrite lines. The abnormal structure (Fig. 6) consists of rounded, not so well defined, and much smaller areas of pearlite, often located in a streaky way. Between these two extreme types all kinds of intermediate structures are obtained with different steels.

The difference in core is similar to that obtained in the gradation zone. Figs. 7 and 8 show normal and abnormal steel after and before carburising. Before carburising the structure of the two steels is very similar, but after the grain size in the normal steel has grown, as might be expected after a prolonged heating above the Ac3 point, whereas the abnormal steel shows an actual decrease in grain size. The pearlite in the normal steel forms comparatively large sharp-cornered areas, whereas the pearlite areas in the abnormal steel are rounded, much smaller, and less well defined in outline.

A difference in structure of the same kind would, of course, have been produced by an anneal at the same heat, and this accounts for the difference in structure that is sometimes observed in low-carbon steels after having been submitted to a normalising anneal around 900 deg. C.

Although somewhat beside the subject under discussion, the writer wants to call attention to the importance of these different properties in steel, when machine parts are subjected to tough anneal and similar heat-treating operations, and the similarity in the problem of securing a steel with good carburising qualities and steels that will respond readily to other kinds of heat treatment.

This difference in grain size disappears with the employment of higher temperatures. This fact accounts for the similarity in structure of normal and abnormal steel before carburising, as, for the different operations in the steel mill, considerably higher temperatures are employed. The only case when it is possible to determine in advance the carburising qualities is when the steel is banded and filled with ghost lines. A steel of this kind is likely to show abnormal carburising qualities, but even this is by no means a certainty.

The structures described above are to be regarded as the extreme limits that can be expected in commercial steels. Both these types are comparatively scarce, and the great majority of cases show structures between these two limits, approaching one or the other. It is, for instance, not unusual to find a gradation zone with large areas of pearlite well rounded. This structure is, as a rule, accompanied by a hypereutectoid zone with a knotty or "clubby" cementite and with a fairly large grain size. Another type of structure shows a small grain size in the gradation zone, but with sharp-cornered areas of pearlite and a fine-grained hypereutectoid zone with well-defined cementite along the grain boundaries. Both in this and the previously mentioned type of steel a tendency for disintegration is often noticed where the cementite lines meet in the corners of the crystals. These two steels approach the normal type and can usually be hardened, although they require a strong spray quench.

An example of a type in the other direction is a structure containing isolated lines of cementite surrounded by ferrite. This type is almost hopeless, as far as hardening is concerned. The same is true of a steel with a tangled mass of cementite and pearlite in the hypereutectoid zone. Another type contains abnormal and normal parts intimately mixed throughout the case and the core (Fig. 9). This structure is regarded with great suspicion as an indication that other parts of this steel might be of unmixed poor quality.

Several authors when writing of carburising give very detailed and exact figures as to the depth of case and the maximum carbon content that will be obtained with different carburising reagents and different temperatures. How they have been able to obtain these figures down to 0·001 in. is a mystery to the author, as it is hardly possible to obtain the depth of case in a microscope closer than within 0·005 in., and even to obtain figures of this accuracy personal judgment is necessary. The depth of case is seldom exactly the same all around a piece, and two pieces carburised close together in the same pot often show a difference of up to 0·005 in., which of course is of no commercial importance, but nevertheless true in spite of all the claims to the contrary made by agents for different carburising compounds. As regards the influence of the steel on the depth of case, the author could give figures from carefully-recorded tests and a laboratory scale, but rather than giving these prefers to relate the experience of his own carburising department. Cones are usually packed inside the cups, of the same bearing, but it is not unusual to receive a report from the carburising department that this packing schedule has to be changed for certain lots, due to a slower penetration in either the cups or cones than normal. On investigation it is always found that the parts that were slow in carburising were made of abnormal steel. Laboratory experiments verify this experience, and although it is hard to give exact figures a maximum difference in depth of case of 15 per cent. to 20 per cent. can be considered as a fairly good value. This statement is valid only for temperatures around or below 900 deg. to 925 deg. C., whereas at higher temperatures an abnormal steel will appear to carburise as fast or even faster than a normal steel. On this point the author is,

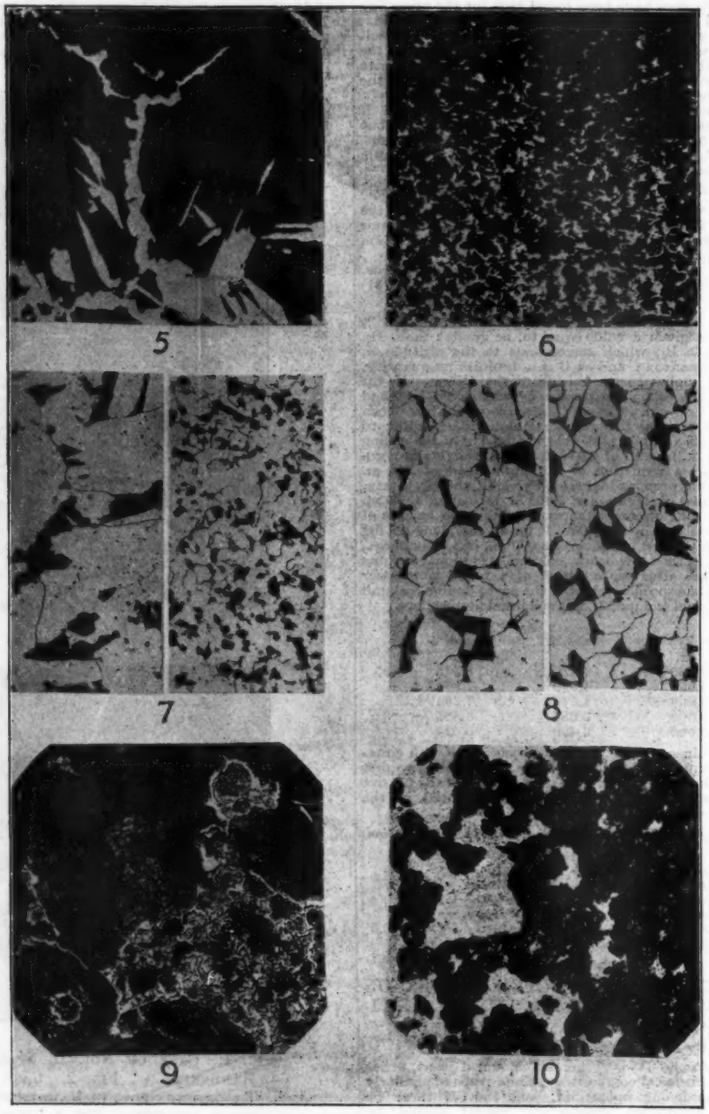


FIG. 5. GRADATION ZONE OF NORMAL STEEL. × 100. FIG. 6. GRADATION ZONE OF ABNORMAL STEEL. × 100. FIG. 7. CORE OF CARBURISED NORMAL AND ABNORMAL STEEL. × 100. FIG. 8. SAME STEELS AS FIG. 7 BEFORE CARBURISING. × 100. FIG. 9. HYPEREUTECTOID, ONE WITH MIXED NORMAL AND ABNORMAL STRUCTURE. × 200. FIG. 10. EDGE OF SOFT SPOT IN HARDENED ABNORMAL STEEL. × 200.

however, not ready to make any positive statements, as this experience is based only on laboratory tests with a few specimens, and on a limited scale.

This feature in an abnormal steel of giving a shallow case is combined with a tendency towards a higher maximum carbon content at the surface. On account of the pearlite divorce it is usually impossible to determine microscopically with any accuracy the carbon content in the case of a steel of this kind, and an inexperienced observer is even likely to judge a very high-carbon case to be hypereutectoid or strongly decarburised. A normal steel gives no difficulty in this respect. It is thus necessary to resort to a chemical analysis, which of course anyway gives the only absolutely reliable figures. In one test two test rings of identical shape, made of different steels, were packed close together in the same carburising pot. The first cut of 0·010 in. showed a carbon content of 1·20 per cent. in the abnormal, as compared with 1·07 per cent. in the normal steel. This is a very undesirable feature, and makes the hardening of the abnormal steel still more precarious.

It is also noticed that the hypereutectoid zone of a strongly abnormal steel shows a more pronounced demarcation at the eutectoid zone than does a normal steel. This is caused by a stronger enfoliation during the cooling, as it is well known that at carburising temperature the carbon content decreases uniformly from a maximum at the surface to a minimum represented by the carbon content of the core. This enfoliation is caused by the strong repelling action on the carbides from the impurities present in abnormal steel. (Compare the formation of ghost lines in steel.) This feature is also, by the way, a direct parallel to the fact that a nickel steel, which contains the nickel in solid solution in the ferrite, shows more enfoliation than a chromium steel, where the alloying element is contained mainly as double carbides.

Hardening of Normal and Abnormal Steel.—Briefly stated, normal steel will respond to heat treatment readily, and in the hardening operation will form martensite and become uniformly hard, while the abnormal steel will not respond readily, and in its worse varieties will not under any circumstances harden without soft spots. These soft spots are of irregular shape, size and distribution. To a file they are more or less soft, and scleroscope readings run from 45 to 60, as against 75 to 90 for normal steel. Microscopical examination shows their structure to be more or less (and sometimes entirely) troostitic (Fig. 10). On rehardening a carburised piece of this kind it is often found that the previously soft areas become hard, but also that, almost invariably, new soft spots develop. In less extreme cases it also happens that the hardening is so far successful that the work appears hard to the file, but shows a soft surface after removing by grinding off a few thousands of an inch. That this phenomenon is not due to careless grinding, but to a hardness only surface deep, has been carefully checked.

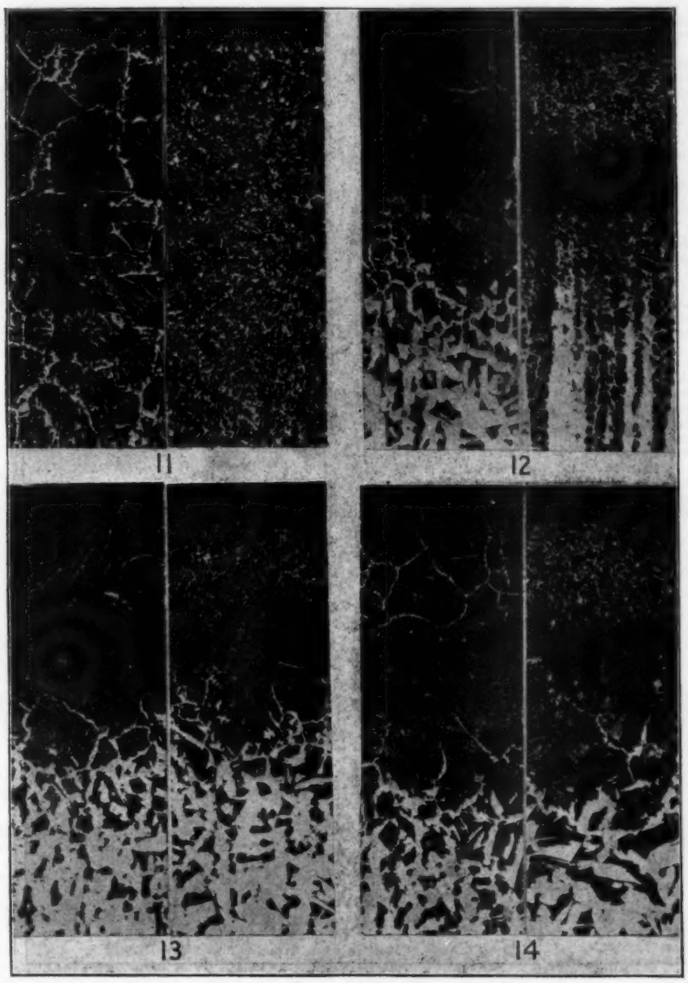


FIG. 11. CASE OF NORMAL AND ABNORMAL STEEL WITH SLOW CARBURISING COMPOUND. CARBON CONTENT ABOUT 70 PER CENT. × 50. FIG. 12. CASE OF NORMAL AND ABNORMAL STEEL, 8 HOURS AT 925 DEG. C. × 50. FIG. 13. CASE OF NORMAL AND ABNORMAL STEEL, 8 HOURS AT 975 DEG. C. × 50. FIG. 14. CASE OF NORMAL AND ABNORMAL STEEL, 2 HOURS AT 1040 DEG. C. × 50.

Somewhat more unusually cases are found where the entire surface is soft. In one case, for instance, the carbon content was found by analysis to be 1·10 per cent. in the outside layers, and in spite of extreme care in hardening under the author's personal supervision the pieces were so soft that there was no difficulty in removing the entire case by filing. Failures in hardening of similar kinds have from time to time been referred to the author for investigation from different manufacturers of case-hardened parts, and the failures have almost invariably been found to be due to more or less abnormal steel. It is often noticed that the surface of an abnormal steel after carburising is spotted and unevenly coloured, whereas the surface of a normal steel with the compound used gives a clean, uniformly grey surface. A similar difference is sometimes observed also after hardening.

The primary considerations in hardening of carburised work as in all other hardening, are the hardening temperature and the accomplishment of a proper quench. The problem of hardening carburised normal steel is similar to that of hardening well-made tool steel. Quite other precautions both as to temperature and quench must, however, be taken with abnormal steel, as the temperature must be raised and the quench made much more drastic than is necessary for normal steel. These points will be dealt with separately.

A normal steel will, in the absence of excess cementite, give a properly refined case if hardened from 770 deg. to 780 deg. C. This applies to work of small dimensions, but even for large-size work the temperature should never need to exceed 790 deg. to 800 deg. C., and if a higher hardening temperature be employed a coarse overheated fracture will be obtained. An abnormal steel behaves entirely differently in this respect, and gives a fine-grained fracture even if the hardening heat be raised considerably above normal. It has even been found that in the case of the most abnormal steels, specimens quenched directly from the carburising pots show fractures of the case resembling those of well-hardened, high carbon chromium steel, whereas of course a normal steel quenched under the same conditions shows a very coarsely-grained fracture.

Independent of the hardening temperature, very abnormal steel will harden with soft spots, but it has been found that with many of the intermediate types of steel an increase in temperature is beneficial. By using a hardening temperature up to 850 deg. C. a large amount of work can be salvaged, although this process is far from 100 per cent. efficient. The proper hardening heat is determined by gradually raising the temperature, testing the hardness by file test, and breaking samples for examination of the fracture. This increase in temperature must be carefully watched, as different steels respond in different ways, and the cases where a fine-grained fracture is entirely independent of the hardening temperature are restricted to the steels distinctly abnormal. Great care must also be taken, by periodical breaking of samples, that no work of normal steel is given this hardening at a higher temperature, which would result in a coarse-grained, entirely unsatisfactory fracture and inferior quality. In this respect the previously mentioned spotty appearance of some lots of abnormal steel is also a good indication.

The soft spots are sometimes accompanied by a somewhat fiery coarse-grained fracture that cannot be refined by the employment of any hardening method. The fracture is somewhat similar to that obtained when the case, for one reason or another, is a little high in excess carbon, but is of a distinctly different nature, and is undoubtedly due to some abnormality in the steel. The exact nature of this has, however, not yet been established, primarily because this fracture is comparatively scarce. The fracture has been observed in several types of abnormal steel, but is especially obtained when the steel in the carburised condition shows signs of pearlite divorce around isolated lines of cementite combined with a fairly large grain size.

In order to avoid any doubt as to the accuracy of the temperatures given, they were all checked by recording instruments of potentiometer type in connection with platinum platinum-rhodium couples, checked periodically against standard couples. The hardening furnaces were of rotary hearth type with central combustion chamber for oil or gas, and the temperature was controlled within ± 2 deg. to 3 deg. C. by automatic regulators of special design.

It has been suggested that the reason for the failure in hardening abnormal steel would be that the cementite in the hypereutectoid zone, once precipitated, could not again be readily brought into solution. This would not, however, explain why samples quenched directly from the carburising pots show soft spots, and it has, moreover, by laboratory experiments with gradually increased hardening temperatures, been proved that the excess cementite is dissolved without difficulty. That the troostite formation is due to some other factor detrimental to the formation of martensite is, the author considers, above doubt. Attention is, however, directed to the parallel of unstable pearlite in the carburised and unstable martensite in the hardened steel, notwithstanding that in the hardening the troostite formation probably occurs directly from the austenite and does not pass the martensitic stage.

In the hardening of common tool steel a faster quench than immersion in brine or flowing water is seldom necessary, and this is equally true of carburised work made from normal steel. The extreme types of abnormal steel can, however, not be hardened under any conditions, and even intermediate types need a faster quench than that obtained by immersion of the work. This fact and the possibilities of much greater production have led to the adoption of a very powerful spray quench in specially-designed hardening machines, working with water under a minimum pressure of 40 lb. to 50 lb., and a maximum temperature of about 15 deg. C. The use of this machine, by the way, also facilitates the use of different quenching mixtures, resulting in a minimum warpage and uniform change in size. By this method all except the very worst types of steel can be satisfactorily hardened, especially if, in doubtful cases and for large work, the hardening temperature is raised as previously mentioned.

It is, of course, desirable to keep the carbon content as close to eutectoid as possible, but this is, especially for heavy cases, very difficult. When excess carbon is present in a normal steel the result will be a freckled edge, but the hardness is not materially affected, even if the strength be lowered. The author's experience with abnormal steel is that the difficulty in hardening, as regards soft spots, is greatly increased with the presence of excess carbon. This experience agrees well with the results by Portevin and Garvin on the influence

of the rate of cooling on hardening of carbon steels.* Their investigation proved that a faster rate of cooling is necessary for the proper hardening of hyper- and hypo-eutectoid than for eutectoid steel. This condition makes it still more difficult to harden an abnormal steel, which, as already mentioned, has a tendency to build up a higher carbon case than a normal steel, and it can be safely stated that even with steels of very abnormal types, the presence of excess carbon (10·5 per cent. or more) is a necessary condition for the complete development of a soft surface in the hardening. As this condition is likely to be present in large size work with heavy cases, most of the difficulty in hardening is experienced with work of this kind. A contributing factor to this is, of course, also that the speed of quenching is slower for large than for small work.

Based on this principle of keeping the carbon content as close to eutectoid as possible, a method of salvage has been worked out that has been used with at least fair success in several instances where the work failed in hardening. The method consists simply in heating the work in a non-carburising medium, such as sawdust or petroleum coke, for long enough to allow of the diffusion of the excess carbon towards the core, and as this diffusion has a tendency to stop at the eutectoid composition, a case of the proper carbon content is easily obtained. In the subsequent hardening operation much better results are obtained, and the author has, although the method is far from fool-proof, been able to save in this way several lots of especially large work that were ready for the scrap pile.

PART II.—INFLUENCE OF CARBURISING TEMPERATURE AND RATE OF COOLING ON THE CARBURISED STRUCTURE OF NORMAL AND ABNORMAL STEEL.

The structures described in Part I were obtained with a carburising temperature of 900 deg. to 925 deg. C., followed by a cooling in the pot. In order to develop a carburising test that could be made on a laboratory scale and in the shortest time possible, experiments were run with higher carburising temperatures and other changes that seemed likely to produce a rapid result.

For the test specimens two bars, one of normal and one of abnormal steel, were packed with different compounds in small containers of 1¼-in. by 6-in. steel pipes. The containers were heated in an electric furnace at 875 deg., 925 deg., 975 deg., 1,040 deg. and 1,100 deg. C., for varying lengths of time. One set of containers was also heated in a high-speed steel furnace at about 1,200 deg. C. The influence of the rate of cooling was studied by cooling at four different rates, as will be shown shortly.

The variation in structure produced by different compounds is very slight. A fast carburiser will, however, give a test in a shorter time, and the carbon content in the case will be higher, which, as already mentioned, is favourable to the development of the differences in structure, and compounds giving an eutectoid case are on this account not well suited for tests of this kind. Very slow carburisers, for instance coke with a weak energiser such as glue, will give a hypoeutectoid case, and the difference in structures obtained is similar to that in the gradation zone, but is much more pronounced, and affords sometimes a very sensitive test (Fig. 11). The influence of time is comparatively small, although a long heating accentuates the difference, due to the fact that a deep case always has a tendency for a higher carbon content in the surface. With a temperature of 925 deg. C. and an energetic compound a very distinct difference is obtained in 2 hours or 3 hours, but for actual tests 3 hours to 4 hours are to be preferred.

There are, as already mentioned, two distinct and different features characteristic of the structure in a carburised piece, namely, the hypereutectoid zone and the gradation zone and the core. In an abnormal steel the structure in both these respects is changed with an increased temperature, but the change does not occur at the same temperatures. With the steel used for the tests the change in structure of the gradation zone and the core occurred at 950 deg. to 975 deg. C., whereas the change in the hypereutectoid zone occurred at 1,025 deg. to 1,050 deg. C. The structure in the normal steel at these temperatures remained practically unchanged (Figs. 12 to 15).

The gradation zone and the core in an abnormal steel are, with low carburising temperatures, fine-grained, with rounded pearlitic areas. With an increased carburising temperature this structure gradually disappears and a structure identical with that of a normal steel is obtained. With the two steels tested the dividing temperature range was 950 deg. to 975 deg. C., but this temperature is likely to vary with different steels, being higher for the very abnormal types.

The structure of the hypereutectoid zone of an abnormal steel at low carburising heat is fine-grained, with knotty or curly cementite and more or less disintegrated pearlite. In the tests made, this structure gradually disappeared with an increase in the carburising temperature, but persisted to a considerably higher point than the structure in the gradation zone and the core. The dividing temperature range was 1,025 deg. to 1,050 deg. C., and somewhat dependent on the carburiser employed, the higher temperature corresponding with a very energetic compound. Above this temperature both the normal and the abnormal steel showed a tendency to form a needle-like structure, although a slight difference was noticed up to about 1,100 deg. C. At still higher temperatures the structure was identical in both steels, consisting of solid pearlite with the cementite as very pronounced needles (Fig. 16).

The influence of the rate of cooling is considerably less than might be expected from previous investigations, and is quite overshadowed by the influence of the quality of the steel. The different rates of cooling and how they were obtained are shown in the following table. The table refers to the tests run at 975 deg. C., but the rates obtained at other temperatures were similar.

——	975 Deg. to 900 Deg.	900 Deg. to 800 Deg.	800 Deg. to 700 Deg.
	hr. min.	hr. min.	hr. min.
1. Pipes cooled in furnace..	1 15	2 30	8 30
2. Pipes cooled in kieselguhr	0 6½	0 4	0 4
3. Pipes cooled in air ..	0 4	0 2½	0 2½
4. Specimens cooled in air..	975 deg. to 700 deg. in about 2 minutes.		

At the slowest rate of cooling there is a very pronounced enfoliation of the case and segregation both in the case and the core, as could be expected, but otherwise the structure is very similar to that obtained in the regular practice, and with the pipes cooled in kieselguhr or in the air (Figs. 17 and Figs. 12 to 16 respectively).

Specimens cooled freely in the air showed, on the other hand, a very pronounced difference with the enfoliation and segregation almost entirely suppressed. At the edge the excess cementite has not had time to segregate, but is precipitated uniformly through the pearlite, and the gradation zone and the core, especially at the higher temperatures, have a tendency to show the typical triangular structure of overheated steel (Fig. 18). At a slightly slower rate of cooling this structure is modified by coagulation phenomena, as previously shown.

In order to obtain the greatest difference between different steels it is desirable that the structure be well developed both in the hypereutectoid and the gradation zones, although these requirements are to a certain degree contradictory. The most distinct difference in the hypereutectoid zone is obtained at about 1,000 deg. C., but at this temperature the transition zone will be coarse-grained, independently of the quality of the steel. In order to develop the typical fine-grained structure in this part and in the core of an abnormal steel it is thus necessary to use a lower temperature. The best results seem to be obtained at 900 deg. to 925 deg. C., and by using an energetic compound and small containers the tests can be made in a total time of 3 hours to 4 hours.

One method by which very fast and satisfactory results are obtained is carburising under pressure. The easiest way to effect this is by using closed containers, preferably made of some heat-resisting alloy, with tight-fitting covers and a carburising meal that gives off plenty of gases during the time of heating. In a commercially conducted carburising these gases are allowed to escape, but can be utilised to build up the desired pressure. In this way it is possible to obtain a distinctly hypereutectoid zone in a short time at a comparatively low temperature. Very sensitive results are also obtained by using a very slow carburising compound at a temperature of about 950 deg. C. In this way a maximum carbon content of 0·60 per cent. to 0·70 per cent. is obtained, and the difference in structure is often very pronounced. For an all-round test the method with a fast carburiser, capable of producing a hypereutectoid case, is, however, to be preferred.

*Conclusion.**—The results obtained in commercial carburising are, as shown in this paper, very much dependent on the quality of the steel, and as these qualities cannot be determined by the usual chemical

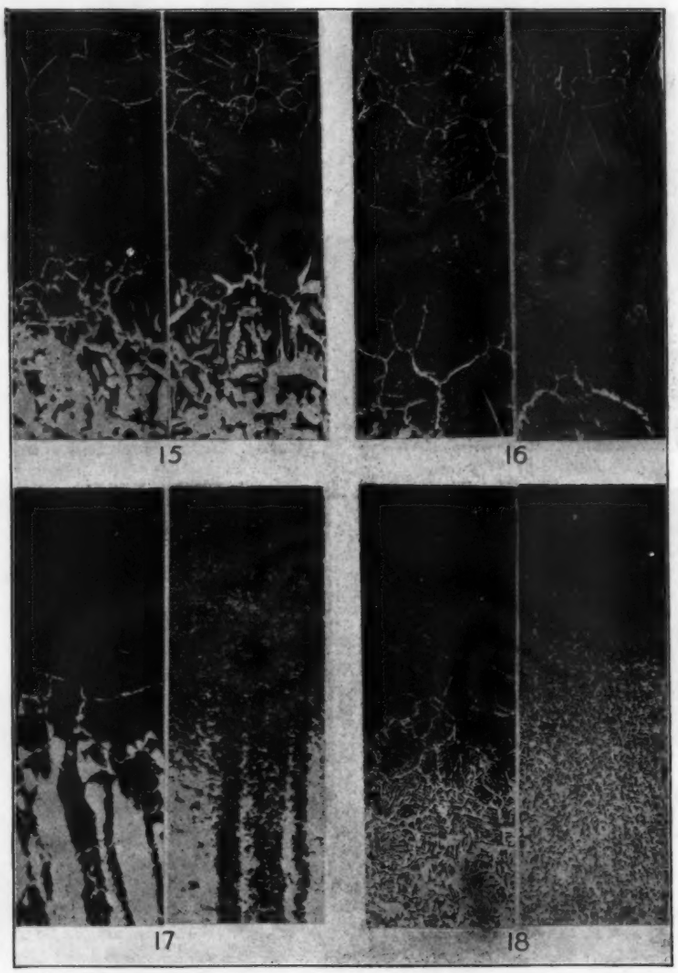


FIG. 15. CASE OF NORMAL AND ABNORMAL STEEL, 2 HOURS AT 1,100 DEG. C. × 50. FIG. 16. CASE OF NORMAL AND ABNORMAL STEEL, 2 HOURS AT 1,200 DEG. C. × 50. FIG. 17. NORMAL AND ABNORMAL STEEL, CARBURISED AT 875 FOR 8 HOURS, COOLED VERY SLOWLY. × 50. FIG. 18. NORMAL AND ABNORMAL STEEL, CARBURISED AT 875 FOR 8 HOURS, SPECIMENS COOLED IN AIR. × 50.

* Journal of the Iron and Steel Institute, 1919, No. I, pages 469 to 560.

* We regret that pressure on our space compels us to omit Parts III and IV of the paper which deal, respectively, with the experimental evidence that the difference in structure and properties in carburised steel is due to oxides in solid solution and with the theoretical explanation of the structures and phenomena described.—ED.E.

or physical test methods, the practical value of a carburising test is obvious. A better product with uniform hardness, less operating trouble, and fewer rejections due to improper hardening, would be the ultimate result.

It is necessary for tests of this kind that microscopical examinations of carburised sections be made; but these do not, if properly conducted, involve a large amount of work, and after a little experience it becomes a very easy matter to determine from the carburised structure whether the steel is suitable for carburising or not. Carburising on a laboratory scale can be carried out in a few hours, especially if some kind of tight-fitting containers are employed in accordance with the recommendations made in Part II. It must be understood however, that a test of one specimen from a large heat, of open-hearth steel is not a perfect safeguard against improper steel, as different parts of a heat often show different carburising qualities. Even one sample from each heat is, however, likely to catch the worst cases, and if several samples from each heat are tested, a

FIG. 19. CARBURISED SPRING STEEL THAT GAVE GOOD RESULTS IN HEAT TREATING. × 200.

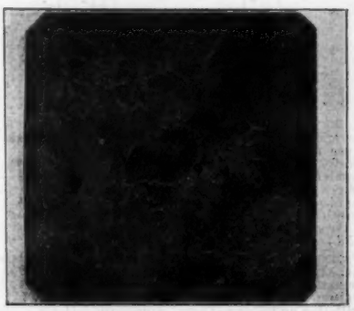


FIG. 20. CARBURISED SPRING STEEL THAT SHOWED ERRATIC RESULTS IN HEAT TREATING. × 200.

reasonable security against improper steel should be obtained. Tests of this kind constitute, moreover, a distinct warning to the steel mills not to send their off-heats to consumers who are known to submit the steel to tests of this kind.

For most carburising purposes, a clean, well-made, straight low-carbon steel (S.A.E. 1,020) would be satisfactory, expecially if hardened by spray quench to counteract small variations in the steel. Owing to the difficulty of obtaining a steel of this kind of uniform and proper quality in the open market, the author is inclined, however, to recommend for general carburising purposes a steel with 0·30 per cent. to 0·50 per cent. chromium. For parts subjected to a very severe service, steels with higher content of alloys such as chromium, nickel and vanadium, can be recommended, although for ordinary purposes out of the question owing to the higher price. A slight percentage of chromium, such as suggested, would give a steel of good carburising properties, as it is very unusual to find a chromium steel with abnormal properties, would not raise the price very much, would rather help than impair the machining qualities, as straight S.A.E. 1,020 steel often tears under the tools on account of being too soft, would increase the rate of penetration in the carburising somewhat, would be beneficial for the hardening, and, last but not least, would necessitate carefully deoxidised heats, as otherwise so much chromium would be lost in the furnace that the chromium content in the finished steel is likely to be lower than specified, and thus detectable by chemical analysis.

The author would finally call attention to the important fact that this influence of oxides in steel is not restricted to carburised low-carbon steel only. They will, if present, materially influence the results obtained in heat treating and hardening of any steel. In the preceding, the probable influence on grain size and structure of work submitted to tough annealing operations, and on the spheroidising of the cementite in annealing high-carbon steels have been mentioned. It is an interesting fact that by carburising high-carbon steels so as to obtain a carbon content of 1·10 per cent. or over, a very sensitive test on the degree of deoxidation is obtained, and that in several instances it has been possible to prove by this method that failures in hardening were due to the presence of oxides in the steel. A well-deoxidised, high-carbon steel should give the structure described as normal in this paper, while abnormal properties are revealed mainly by irregular grain size. Figs. 19 and 20 show, for instance, the edge of two carburised pieces of spring steel, the first of which was reported to have given excellent results in heat treating, while the results with the latter were erratic and irregular. The two steels were of approximately the same analysis, with the same physical properties, and with no difference in the microstructure before carburising. Several similar instances could be given, with the results agreeing closely with the record of service for the different steels. Many failures, especially in hardening, are likely to find their explanation on tests of this kind, and perhaps even the mysterious property of steel known as "body" might ultimately be explained by the presence or non-presence in the steel of non-metallic impurities, presumably oxides in solid colloidal solution.

In conclusion, the writer wishes to express his sincere gratitude for the interest, help, and advice extended him by Messrs. M. T. Lothrop and H. W. McQuaid of the Timken Roller Bearing Company. He is also grateful to Professor E. D. Campbell of the University of Michigan, Ann Arbour, for valuable advice, and to Professor H. M. Boylston of the Case School of Applied Science, Cleveland, for important steel samples.

EXPLOSION OF A BOILER AT A COLLIERY.

A PRELIMINARY inquiry, under the provisions of the Boiler Explosions Acts, 1882 and 1890, has been conducted by the Board of Trade with regard to the cause and circumstances of an explosion of a boiler which occurred on November 16, 1921, at the Giffnock Colliery, Thornliebank, Renfrewshire. Although the explosion was not of a violent nature, a boy was, unfortunately, killed.

The boiler was the property of the Giffnock Collieries, Limited, 75, Bothwell-street, Glasgow, and was of the wrought-iron Lancashire type, 7 ft. mean diameter by 30 ft. long, with flat ends ⅞ in. thick, connected to the shell plating in each case by an inside angle ring 3 in. by 3 in. by ½ in. thick. These flat ends were stiffened at the top of the boiler by four gusset stays and two bar stays, 1⅛ in. diameter. One gusset stay on the midline between the flues supported the back end plate at the bottom of the boiler. A manhole, 16 in. by 12 in., was placed between the furnaces on the front end plate, which was without bottom gusset stays. The boiler had two plain flues, tapering from 32 in. external diameter at the front to 28 in. at the back end, made of $\frac{7}{16}$ in. plates. Six cross-tubes were fitted to each flue. The shell was built in eight belts, with two plates, ½ in. thick, in each belt. The circumferential seams were single-riveted lap joints with ¾ diameter rivets placed 2 in. apart. The longitudinal seams were double riveted lap joints with ⅞ diameter rivets, 2¼ in. apart. The boiler was provided with all the usual mountings, including two lever safety valves, 4 in. diameter.

The boiler was purchased second-hand from a broker about seventeen years ago, having previously been in use at another colliery, and was about twelve years old when purchased by the Giffnock Colliery. The age of the boiler was, therefore, probably at least thirty years. It was made by Messrs. Pearce Brothers, of Dundee, a firm now out of business.

Under the Coal Mines Act, 1911, a prescribed form of book for reports on quarterly internal examination of steam boilers was kept at the colliery. Under date February, 1920, this showed that a new blow-off block was riveted to the boiler shell. The records kept did not go sufficiently far back, but about 4½ years ago two strengthening rings were fitted to each of the boiler flues.

The boiler was insured by the Scottish Boiler and General Insurance Company, Limited, 82, St. Vincent-street, Glasgow, and was periodically inspected by their inspector, Mr. Rankin Kennedy, an experienced engineer who has been employed as a boiler inspector for the past twenty-three years.

Mr. J. Dow, engineer-surveyor to the Board of Trade, in his report states the boiler was the centre one of a range of five boilers, standing exposed to the weather at the colliery. It was used to drive the new pit-winding machine, the smith shop, and the feed pumps for the whole range of boilers, and was certified for a working pressure of 80 lb. per square inch at the time of the explosion.

On Tuesday, November 15 last, the boiler fireman came on duty at 9.30 p.m., and was accompanied by William Cairns, the ash boy. There was steam on all the boilers except No. 2, the one immediately to the left of No. 1 boiler, and on No. 1 boiler the pressure was 60 lb. per square inch. About 1.30 a.m., while on his way to No. 3 boiler, the fireman stopped in front of No. 1 and observed about 7 in. of water in the glass. At the same time he blew through the glass of the boiler. This boiler had been working the new pit during the night and the pressure had fallen at one time to as low as 40 lb. per square inch. When the glass was blown through as mentioned, the pressure was then about 62 lb. per square inch. The feed pump was kept going continuously and the feed check valve of No. 1 boiler was open a little all night. Having repaired the fires of No. 3 boiler, the attendant stopped in passing and again examined the gauge glass of No. 1 boiler, and found there was still 7 in. of water there. He had just passed to the front of No. 4 boiler when the explosion occurred. He jumped into a doorway opposite the boilers, and water and dross were splashed as high as his face. The ash boy was walking behind the fireman. Help soon arrived, but no one could get near the boilers. Not a sound was heard from Cairns, and it was realised that he had been caught by the explosion. When the steam had sufficiently cleared away, they found him, lying in front of the exploded boiler, covered with dross.

Mr. Dow, after an examination of the exploded boiler, states that the shell plate cracked circumferentially along the line where it joined the inside angle ring at the bottom of the front end of the boiler. The crack extended for about 28 in. on each side of the bottom point of the circumference, and was thus about 56 in. long. It opened out to about ¼ in. at the middle of its length, tapering to nothing at the ends.

On September 22 last, Mr. Kennedy, boiler inspector to the Scottish Boiler and General Insurance Company, Limited, thoroughly examined No. 1 boiler. He was accompanied by Mr. James Yardley, the mechanical engineer at the colliery, who had been with the Giffnock Company for the past fourteen years, and was responsible for the maintenance and running of the steam plant at the colliery. In preparation for this examination the "Vee" wall forming the recess round the blow-off cock was taken down, the flue door brickwork on each side of the boiler was removed, and the bricks below the front circumferential seam were removed as might be required. It appears that the outside of the shell at the front end was found dirty and covered with a damp scale when the bricks were removed. The inspector sounded the shell there with a hammer, and stated that as a result it was quite clear to his mind that the plate was of ample thickness for safety. In his report of September 22, Mr. Kennedy stated that "the shell plate of No. 1 boiler was wasted between the rivet heads in the first circular seam lap at the sides and bottom from $\frac{1}{16}$ in. to fully ¼ in. deep, and the heads of the rivets from ¼ in. to fully $\frac{1}{16}$ in. in depth."

Mr. Dow, continuing his report, states that the actual wastage was ⅜ in. and the actual thickness along the line of fracture was only ¼ in. at the time of the explosion which was barely eight weeks after the report of September 22. It was probable that owing to the presence of a hard scale on the sides and bottom of the shell, and the stiffening afforded by the leaf of the inside angle ring, the hammer test would fail to reveal the weakness due to external corrosion that undoubtedly existed at the time of this thorough examination. The front end of the boiler was freely exposed to the weather. The brickwork beneath it was supported on angle bars and served merely as an ash fender. It was also exposed to the action of wet ashes and the hose used for cooling them. The lower part of the front of the boiler was cut off from contact with the flue gases by the recess wall, and this part was peculiarly liable to suffer from corrosion where in contact with the brickwork. The inside of the boiler was in a good state of preservation and free from corrosion. Along the line of fracture no sign of grooving or wasting internally could be detected. Notwithstanding the favourable appearance of the boiler generally—which was known to be about thirty years old—it was, Mr. Dow states, a grave error of judgment on the part of the inspector of the boiler insurance company, and also on the part of the mechanical engineer for the users of the boiler, when they failed to apply a drilling test on September 22 last, which would have shown clearly that a new shell plate was required for the bottom front end of the boiler at that time.

The cause of the explosion was the wasting away of the shell plate externally, in consequence of which the boiler was no longer able to withstand the pressure of steam to which it was subjected.

Reviewing the above report, Mr. Thomas Carlton, the Engineer Surveyor-in-Chief to the Board of Trade, adds the following observations: "This report deals with the explosion from a boiler which was known to be about thirty years old. Wastage at the part which ultimately failed appears to have been recognised by those in charge, as well as by the insurance company's inspector, but unfortunately they did not realise that the corrosion had proceeded so far as to be dangerous. Smooth wasting over a considerable area is perhaps deceptive, though it is well known to exist, and, in consequence, if any possible doubt should arise the parts should be drilled and the thickness ascertained with some degree of certainty."

THE POWDERING OF MINERALS BY DECREPITATION.—It has long been known that rock salt, lead nitrate and some other minerals will decrepitate when dropped on a hot plate or when heated. This breaking-up on heating, with almost explosive violence, is ascribed to the inclusion in the crystal of water, and it has been utilised for the separation of minerals which are too nearly of the same density to be concentrated by water-washing, notably for the separation of zinc blende and barytes, barium sulphate. The ores are heated, up to 200 deg. C. or less, in revolving or reverberating furnaces and then screened, when the powdered barytes can be sifted from the coarser grains of the blende. This process is carried out in America and other countries, and also by the St. Asaph Zinc, Lead and Barytes Company in this country. Experimenting on the suitability of the various barytes mined in this country, Professor T. M. Lowry and Mr. L. P. McHatton, of Cambridge, pointed out in a paper read before the Faraday Society last month, that all the English barytes will decrepitate, except those from Durham, which are soft and earthy in texture, whilst the others are marble-like. The more water the mineral contains, the finer will generally be the powder produced by decrepitation; the actual percentage need not be at all large, and may, in the barytes, be as low as 0·04 per cent. Celestine, strontium sulphate, and crocoite, lead chromate, also decrepit when they contain a small amount of water.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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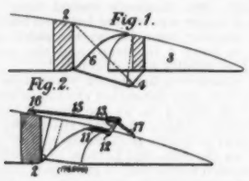
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

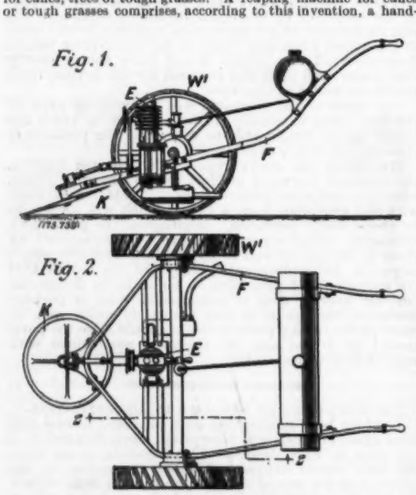
176,909. F. Handley-Page, Cricklewood, and Handley Page, Limited, Cricklewood. Balancing and Regulating Aircraft. (12 *Figs.*) December 21, 1920.—When flaps or ailerons hinged to the trailing portion of the wings are turned downwardly, slots between the wings and the flaps, or in the wings, or in the flaps, are uncovered, so that air can pass from the underside of the wing to the upper side of the flap without abrupt change in direction. When the flap 3, Fig. 1, is turned downwardly about its pivot 4, a slot is opened between the flap and the fairing 6 behind the main spar 2 of the wing. When the slot



is formed in the wing, it is closed when the flap is in its normal position or is moved upwardly by a cover plate fixed to the flap and sliding over the slot, and is opened when the flap is moved downwardly. When the slot is in the flap, it may be normally closed by a cover plate fixed to the wing and sliding over the upper surface of the flap; or the slot may be closed by a shutter 11, Fig. 2, pivoted at 12 and held in the closed position shown by a spring 17, but adapted to be opened, when the flap is turned down through the engagement of the arm 13 with a slot in a rod 15 anchored at 16 to the wing. (*Accepted March* 29, 1922.)

AGRICULTURAL APPLIANCES.

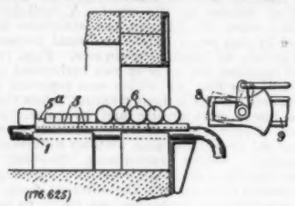
175,759. Sir Percy Scott, London, and A. F. Maclaren London. Reaping Machines. (2 *Figs.*) November 23, 1920.—This invention consists in improvements in reaping machines for canes, trees or tough grasses. A reaping machine for canes or tough grasses comprises, according to this invention, a hand-



directed chassis F mounted on only two wheels W1, an internal-combustion engine E mounted on the chassis, and a high-speed rotating cutter or rotating knife K mounted in front of the chassis with its plane of rotation approximately horizontal. The cutter or knife is operatively connected with the engine E in such a way that it is run at a high rate of revolution. (*Sealed.*)

MINING, METALLURGY, AND METAL-WORKING.

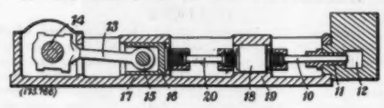
176,628. J. S. Atkinson, Westminster, and Stein and Atkinson, Limited, Westminster. Continuous Furnaces. (4 *Figs.*) February 8, 1921.—This invention has relation to continuous furnaces. In accordance with this invention, there are provided slippers or carriers 5 (hereinafter referred to as slippers) which rest upon the stationary skids 1, and on which the billets 6 are placed. The slippers with the billets thereon are traversed along the stationary skids by endwise pressure applied thereto by the means usually employed to traverse the billets. The head 8 of the billet pusher 9 is adjustable and can be caused to act either on the slippers or on the billets on the slippers. The slippers 5 are made of lengths of metal and each is of a section such that one face or side can be seated on a skid which it then partly encircles; the other face or side provides a flat surface to receive the billets 6. As shown, the slippers 5 are of a length to permit several billets 6 to rest thereon. The slippers 5 may be of one section throughout their length or, as shown, some of the slippers may be formed or provided



at one end with a shoulder or boss 5a. The shoulder or boss 5a provides a large bearing surface on its outer face to contact with billets 6 that have been placed directly on the skids 1. (*Sealed.*)

PUMPS.

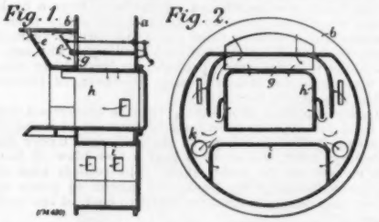
175,766. R. P. Doxford, Sunderland, and K. O. Keller, Sunderland. Reciprocating Pumps. (3 *Figs.*) November 24, 1920.—This invention is for improvements in reciprocating pumps. The pump comprises a ram 10 reciprocating in a sleeve 11, these two parts being machined initially with such accuracy that the leakage at the desired working pressures is negligible. The pump chamber is indicated at 12. The primary driving member is a connecting rod 13 operated by an eccentric 14. The other end 15 of this connecting rod is mounted in a crosshead 16, which is free to slide in a guide 17, and this guide is originally made with its longitudinal axis parallel with and preferably co-axial with the axis of the ram 10. The crosshead 16 absorbs



all the lateral thrust introduced by the obliquity of the driving member 13, and it transmits only a thrust which is initially co-axial with the ram. But when wear of the guide 17 and crosshead 16 takes place, the line of movement of the crosshead is no longer co-axial with the ram, and the transmitted thrust may be not co-axial with the ram. There is therefore provided a second crosshead 18 which slides in a guide 19, this guide being (like the guide 17) initially machined with its axis parallel with the axis of the ram. The two crossheads are connected by a thrust member 20 which is connected to each of them or both of them by a joint which permits displacement of the crosshead relatively to the thrust member in a direction at right angles to their line of movement. (*Sealed.*)

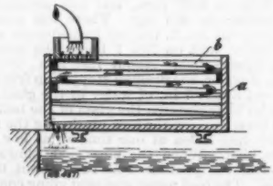
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

174,430. J. Reid, London. Furnace Fronts. (2 *Figs.*) October 22, 1920.—In forced draught furnaces it is common to pass the air through heaters in the uptakes into hollow furnace fronts, each front being provided with valves for controlling the flow of air into the furnace above and below the grate bars. It has been proposed so to construct furnace fronts that air flowing into the furnace will be heated and the furnace front cooled. According to the present invention, for the purpose of heating the air, it is caused to flow into a top baffle *e* extending from the back plate *b* of the furnace front into the furnace, and to pass thence through port *g* into the front proper and flow



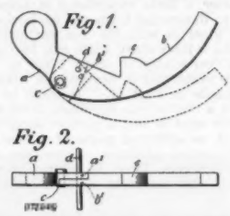
around the fuel passage casing A and an ash pit entrance trunk or casing *i*, extending between the front and back plates *a*, *b* of the front, and finally to flow from the front into the ash-pit through holes *k* formed in the lower half of the back plate *b* of the front. For the purpose of controlling the flow of air, a valve *f* is arranged between the air supply from the fan and the enclosed space *e* within the furnace front, the passages in the front and the ports leading to the furnace being so arranged and dimensioned that the air, the flow of which is regulated by the single inlet valve, is distributed to the several parts of the furnace in the required proportions. (*Sealed.*)

169,487. T. Sergeant, Waterloo, near Liverpool. Steam Engines. (4 *Figs.*) June 14, 1920.—This invention relates to the purification of condensed water of steam engines. According to the invention, a casing *a* is provided with a series of superimposed trays *b* of porous and filtering material over which the



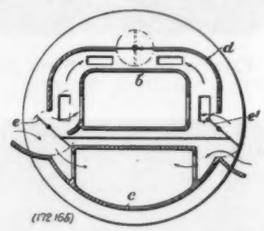
condensed water flows and through which it can percolate. The trays *b* are inclined to the horizontal, and at the lowermost end of each tray an outlet is provided leading to the tray immediately below the same. The space between the trays is filled with filtering material, such as cocoanut fibre, to which the oil and grease adheres. (*Sealed.*)

172,045. D. Ferguson, Mount Florida, Glasgow. Under-Feed Stokers. (5 *Figs.*) June 7, 1920.—A safety link for use with the driving gear of underfeed stokers comprises parts constructed preferably of mild steel and jointed together and normally held rigidly in position by a safety pin, and characterised by a jointed part provided with a recess, one side of which constitutes the side of a projection with which engages a member of the driving gear. The link is made in two parts *a*, *b* connected together by a pivot pin *c*, and each formed with a hole *a*1, *b*1, and adapted to be held rigidly together by a safety pin *d* passed through the holes *a*1, *b*1. The arrangement of jointed parts *a*, *b* is such that, when the link is subjected to an undue pressure or



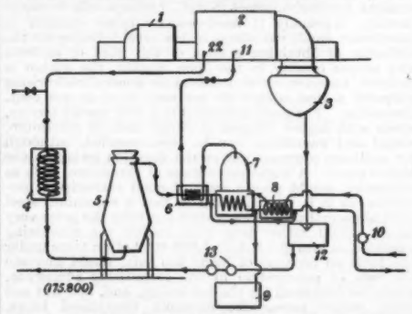
stress, such as that which would be sufficient to damage the stoker operating mechanism, the resistance of the pin is overcome, and it is cut or sheared through and the link is then free to open out, as indicated in dotted lines in Fig. 1, and move to a position to free the driving mechanism, and thereby prevent damage being done to or breakage of the stoker operating mechanism. To enable the driving member of the mechanism to be engaged with the link, the latter is formed with a recess, one side of which is constituted by a projection *e*, for obtaining engagement when the parts are held together by the safety pin *d*. (*Sealed.*)

172,165. J. Reid, London. Furnace Fronts. (2 *Figs.*) September 23, 1920.—The object of the invention is to provide for the smooth and well-distributed flow of air to the ashpit or furnace space under the fire-bars with two side valves, which can be conveniently linked together and interlocked with a furnace door to prevent the latter being opened when the draught is on. According to the invention, the two side valves *e*, *e*1 are so pivoted that when closed they are in vertical or substantially vertical posi-



tions, and are connected so as to move parallel with each other, the one valve *e* thus tending to direct air from one side mainly towards the ash pit flare *c*, and the other valve *e*1 tending to direct air from the other side upwards into the air chamber *d* above the fire-box *b*. The valves are pivoted towards their top edges so as to increase the valve opening at the bottom and reduce the same at the top, the object being to direct a larger volume of air into the ash pit than into the air chamber over the fire-box. (*Sealed.*)

175,800. The Firm Merz and McLellan constituted by C. H. Merz and W. McLellan, Westminster, London and Newcastle-upon-Tyne, W. T. Bottomley, Gosforth, Newcastle-upon-Tyne, and E. G. Weeks, Monkseaton. Fuel Distillation and Steam-Power Apparatus. (1 *Fig.*) December 3, 1920.—This invention refers particularly to a method of and means for obtaining steam for low-temperature carbonisation plant run in conjunction with large power stations, and has special application in cases where the make-up water is not suitable for use in boilers without purification. The present invention comprises a method which consists in passing steam from a steam power unit through a low-temperature distillation apparatus and thence, together with distilled gases therefrom, through heat-exchanging apparatus, passing make-up water therethrough to evaporate it and introducing the clean make-up steam thus produced into the lower plant at a part or at a stage working at a pressure substantially equal to that of the make-up steam.



Steam is bled from the low-pressure stage 2 of a condensing turbine 1, 2, 3, from a position such as 22, and is passed through a low-pressure high-temperature superheater 4 and thence into the lower end of a low-temperature retort 5. The steam and gas leaving the top of the retort pass through one element of each of several heat exchangers 6, 7 and 8, which condense out the tar and water leaving the gas to be passed on to the usual stripping plant. The condensed tar and water are collected in a separate receiver 9. Make-up water is passed by means of a pump 10 into and through the other elements of the heat exchangers 8, 7, 6, respectively, in the reverse direction, the water being evaporated therein. The make-up steam thus produced is at a pressure a little below atmospheric pressure and is passed into the low-pressure stage of the turbine as at 11. The feed water for the boiler is taken from a hot well 12 and is heated in the normal way by a series of feed heaters 13, which are heated by steam bled from the turbine at different points. (*Sealed.*)